FINANCIAL ASSISTANCE
FUNDING OPPORTUNITY ANNOUNCEMENT

U.S. Department of Energy

Idaho Operations Office

Nuclear Energy Research Initiative Program (NERI)

Funding Opportunity Number: DE-PS07-06ID14762

Announcement Type:	**Initial**
CFDA Number:	**81.121**

Letter of Intent Due Date:	**06/12/2006**
Issue Date:	**05/05/2006**
Pre-Application Due Date:	
Application Due Date:	**06/28/2006**

This announcement will remain open until 5:00 P.M. MST June 28, 2006. Applications may be submitted any time before the announcement closes.

NOTE: NEW REQUIREMENTS FOR GRANTS.GOV

Where to Submit: Applications must be submitted through Grants.gov to be considered for award.

Registration Requirements: There are several one-time actions you must complete in order to submit an application through Grants.gov (e.g., obtain a Dun and Bradstreet Data Universal Numbering System (DUNS) number, register with the Central Contract Registry (CCR), register with the credential provider, and register with Grants.gov). See www.grants.gov/GetStarted. Use the Grants.gov Organization Registration Checklist at www.grants.gov/assets/OrganizationRegCheck.doc to guide you through the process. Designating an E-Business Point of Contact (EBiz POC) and obtaining a special password called an MPIN are important steps in the CCR registration process. Applicants, who are not registered with CCR and Grants.gov, should allow at least 14 days to complete these requirements. It is suggested that the process be started as soon as possible.

Questions: Questions relating to the registration process, system requirements, how an application form works, or the submittal process must be directed to Grants.gov at 1-800-518-4726 or support@grants.gov. Part VII of this announcement explains how to submit other questions to the U.S. Department of Energy.

Application Receipt Notices

After an application is submitted, the Authorized Organization Representative (AOR) will receive a series of four e-mails. It is extremely important that the AOR watch for and save each of the emails. It may take up to two (2) business days from application submission to receipt of email Number 2. You will know that your application has reached DOE when the AOR receives email Number 4. You will need the Submission Receipt Number (email Number 1) to track a submission. The titles of the four e-mails are:

Number 1 - Grants.gov Submission Receipt Number
Number 2 - Grants.gov Submission Validation Receipt for Application Number
Number 3 - Grants.gov Grantor Agency Retrieval Receipt for Application Number
Number 4 - Grants.gov Agency Tracking Number Assignment for Application Number

After receipt of email Number 4, you can view your application at DOE's e-Center, http://e-center.doe.gov. A User Id and password are required. If you already have a User Id and password you do not need to re-register.

VERY IMPORTANT – Download PureEdge Viewer: In order to download the application package, you will need to install PureEdge Viewer. This small, free program will allow you to access, complete, and submit applications electronically and securely. For a free version of the software, visit the following web site: www.grants.gov/DownloadViewer.

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PART I – FUNDING OPPORTUNITY DESCRIPTION

A. 1. Background:

Since 1999, the Nuclear Energy Research Initiative (NERI) program has sponsored research to advance the state of nuclear science and technology in the United States by addressing the key technical issues impacting the expanded use of nuclear energy. The program has sponsored research and development on next-generation nuclear energy systems; proliferation resistant nuclear fuel cycle technologies; generation of hydrogen using nuclear power; improvements in light water reactor technology; and fundamental areas of nuclear science that directly impact the long-term success of nuclear energy. The advances in these areas are expected to be incorporated in potential future advanced reactor designs and nuclear fuel systems.

The NERI program is achieving its goal of developing advanced nuclear energy systems and technology to help assure that the United States maintains a viable option to use nuclear energy to meet its energy and environmental needs. The research effort, conducted by the Nation's universities, laboratories, and industries, is helping to maintain the nuclear research infrastructure in this country and has focused attention on the United States as a nuclear research and development leader. Research accomplishments include: reactor system and plant infrastructure concepts that utilize nuclear energy to produce hydrogen; new advanced controls, diagnostic techniques and information systems for potential use in automating future nuclear plants; advanced nuclear fuels that could allow higher burn-ups resulting in maximized energy production and improved plant economics; evaluation of direct energy conversion technologies for advanced nuclear power plants; and reactor physics data for advanced nuclear power systems. Through funding innovative nuclear research at the Nation's universities, the NERI program has also stimulated student enrollment in nuclear fields of study. Further highlights of the NERI program are contained in the Nuclear Energy Research Initiative 2004 Annual Report (see http://neri.ne.doe.gov/).

The NERI program focuses on advanced nuclear research at the Nation's universities and is integrated into the Department's mainline nuclear energy research and development (R&D) programs. The R&D conducted under this activity will directly support the Advanced Fuel Cycle R&D Program, the Generation IV Nuclear Energy Systems Initiative (Generation IV), and the Nuclear Hydrogen Initiative (NHI). This announcement, which is only open to all U.S. universities, provides an opportunity for universities to participate in these research initiatives. The NERI R&D projects will be selected using a competitive, peer, relevancy, and programatic review process. The Advanced Fuel Cycle R&D Program, Generation IV, and Nuclear Hydrogen Initiative provide funding for the NERI awards.

2. Objective:

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The NERI program is intended to conduct R&D to meet the following objectives:

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Directly support the resolution of technical and scientific issues for the Advanced Fuel Cycle R&D Program, the Generation IV Nuclear Energy Systems Initiative, and Nuclear Hydrogen Initiative programs;

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Allow the Nation's universities to participate in the Department of Energy's mainline nuclear R&D programs;

.
Contribute to assuring that a new generation of engineers and scientists are available for the nuclear future.

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STATEMENT OF OBJECTIVES: The Department of Energy is seeking applications from universities for research and development (R&D) that will directly support its nuclear energy R&D in the Advanced Fuel Cycle R&D Program, Generation IV Nuclear Energy Systems Initiative, and Nuclear Hydrogen Initiative programs. Information describing these programs may be found on the Office of Nuclear Energy Web Site at: http://nuclear.gov.

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1. Advanced Fuel Cycle R&D Program

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1.1 Spent Fuel Separations Technology

.
1.2 Advanced Nuclear Fuel Development

.
1.3 Transmutation Engineering Technologies

.
1.4 Advanced Fuel Cycle Systems Analysis

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2. Generation IV Nuclear Energy Systems Initiative

.
2.1 Very-High-Temperature Reactor

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2.2 Sodium Fast Reactor

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2.3 Design and Evaluation Methods Development

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2.4 Crosscutting Materials Development for Advanced Reactors

.
2.5 Energy Conversion

.
3. Nuclear Hydrogen Initiative

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3.1 Thermochemical Cycles

.
3.2 High-Temperature Electrolysis

.
3.3 Reactor-Hydrogen Production Process Interface

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A summary of the R&D needs in each of these program elements

follows. More specific descriptions of representative R&D requests in these program elements are included in Appendix I. Proposed projects may involve work in any activity of these program elements.

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1. Advanced Fuel Cycle Research and Development Program: Initiation of the DOE activities to realize the President's Global Nuclear Energy Partnership (GNEP) vision marks a major change in the direction of the DOE's R&D program on advanced fuel cycles. The Department is implementing a coherent plan to test technologies that promise to markedly reduce the problem of nuclear waste treatment and to reduce the proliferation risk in a world with a greatly expanded nuclear power program. GNEP brings the U.S. program into much closer alignment with that of the other major nuclear energy states.

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GNEP proposes to take spent fuel from existing light water reactors (LWRs), separate the actinides that are the main components contributing to repository problems and to proliferation concerns, and destroy them through multiple recycles in fast-spectrum reactors (FRs). GNEP builds on the technology developed over the past five years for efficiently separating the main components of spent reactor fuel into uranium that can be easily disposed of, fission fragments, mostly of relatively short lifetimes, and the plutonium and other actinides that generate both the waste isolation and potential proliferation problems. It is a bold program that has a high expectation of success, but will require twenty or more years to fully evaluate its promise and to begin large scale implementation. Under GNEP three major systems technology demonstration projects are envisioned to be conducted by DOE:

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· A near-term demonstration of LWR spent fuel separations to provide proliferation-resistant products

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· Demonstration of advanced fuel transmutation in an Advanced Burner Test Reactor (ABTR)

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· Availability of an Advanced Fuel Cycle Facility (AFCF) to provide advanced transmutation fuel assemblies for qualification in the ABTR and provide a long-term advanced fuel cycle R&D capability in the U.S.

These GNEP demonstration projects will also provide the capability of developing advanced instrumentation and monitoring to improve accountability of plutonium and other transuranic elements. Further, they will allow for long-term research and development including technical and cost-effective improvements to proliferation-resistant separations and fuel fabrication technologies.

More detailed information on GNEP can be obtained from the web page, www.gnep.energy.gov, which includes among general information, GNEP fact sheets as well as a copy of the Administration's FY 2007 Advanced Fuel Cycle R&D Program budget submission to Congress.

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Henceforth, the prime focus of the Advanced Fuel Cycle R&D effort will be to support GNEP by:

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· Performing the R&D necessary to implement the above three major GNEP demonstration projects;

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· Identifying and conducting the R&D that these projects will enable; as well as:

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· Continuing R&D on alternative technologies in the event that the primary GNEP technologies do not perform as expected or later require improvements.

1.1 Spent Fuel Separations Technology: The separations technology development component of Advanced Fuel Cycle R&D Program involves the development of advanced methods for the chemical partitioning of spent nuclear fuel into constituents that can be (1) readily disposed of in improved waste forms, (2) recycled for transmutation and/or energy recovery in thermal and/or fast reactor systems, or (3) stored for future disposition (some minor actinides, cesium and strontium). Such partitioning will ultimately require the construction of a large spent fuel treatment facility for processing the output of current and future thermal spectrum reactors, and this facility must incorporate the best available process technologies as well as state-of-the-art instrumentation for process monitoring/control and materials accountancy. There will also be special requirements for the recycle of spent fuel arising from fast spectrum burners that must be met in the future, utilizing advanced spent fuel treatment methods tailored to the unique fuel types of this reactor concept. Proposed projects may involve R&D in the areas of advanced aqueous separations, pyrochemical processing, engineered product storage, and spent fuel treatment facility design/process technology development.

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1.2 Advanced Nuclear Fuel Development: This program element is primarily focused on conducting research and development activities for advanced fuels applicable to fast spectrum transmuter systems. The fuel forms of interest for fast spectrum transmuters include fertile (high uranium content), low-fertile (low uranium content) and non-fertile (no uranium content) compositions in ceramic, metal, oxide, and composite fuels and targets. The general research topics of interest cover wide-ranging areas of fuel modeling, fuel and target fabrication process development, characterization methods, in-pile and out-of-pile testing, advanced instrumentation for in-pile testing, advanced fuel matrix and cladding material development.

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1.3 Transmutation Engineering Technologies: Transmutation engineering provides critical R&D to support advanced fuel cycles, Transmutation is a process by which long-lived radioactive species, particularly actinides (but also certain fission products), are converted into short-lived nuclides by either fission or neutron capture and decay. By changing the decay timescale from millennia to hundreds of years, toxicity and heat load challenges to the U.S. geologic repository fall into the realm of well-known engineering practices, and thus become easier to solve with better certainty of success. Transmutation engineering physics activities are focused in the areas of nuclear data and code validation. Transmutation engineering materials activities are focused on the development and understanding of structural material performance under intense radiation and environmental conditions. Proposed projects may involve R&D in the areas of modeling of material behavior during irradiation, material irradiation performance, material environmental performance, Monte Carlo physics code development, and nuclear data measurements.

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1.4 Advanced Fuel Cycle Systems Analysis: The role of systems analysis is to link the objectives, analyses and technology developments of the Advanced Fuel Cycle R & D program with current operating nuclear plants and future advanced technologies by providing the models, tools, and analyses needed to optimize deployment options and to understand their benefits and impacts. Systems analyses of reactors and processes also will be useful for establishing needs for new technologies. Such studies typically involve energy demand, material flows (both resources used and wastes generated), cost analyses and system comparisons and are ripe for innovative R&D in areas such as computer model development.

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In the intermediate term, the top-level objective for systems analysis is to analyze spent fuel treatment and recycle options for current light water reactors to support a Secretarial recommendation between 2007 and 2010 on the technical need for a second repository. High-level longer-term objectives for systems analysis include cost/benefit analyses of alternative systems and fuel cycles, with an eye to optimizing deployment strategies. In particular, deployment strategies need to consider trade-off options among economics, energy, environmental impacts, and nonproliferation benefits of integrated advanced reactor/fuel cycle systems, balanced by an understanding of their development costs and technology risks.

2. Generation IV Nuclear Energy Systems Initiative

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2.1 Very-High-Temperature Reactor: The U.S Department of Energy (DOE) is conducting research and development (R&D) on the Very-High-Temperature Reactor (VHTR) design concept. The reactor design will be a graphite moderated, thermal-neutron spectrum reactor that will produce electricity and hydrogen in a highly efficient manner. The VHTR reactor core could be either a helium-cooled prismatic graphite block or a pebble bed core. Use of a liquid-salt coolant is also being evaluated. The VHTR will use very-high-burnup, low-enriched uranium, TRISO-coated fuel, and have a projected plant design service life of 60 years.

The VHTR concept is considered to be the nearest-term reactor design that has the capability to efficiently produce hydrogen. The plant size, reactor thermal power, and core configuration will ensure passive decay heat removal without fuel damage or radioactive material releases during accidents.

The objectives of the VHTR Project are to conduct the R&D necessary for a full-scale prototype VHTR that is commercially licensed by the U.S. Nuclear Regulatory Commission, and to demonstrate safe and economical nuclear-assisted production of hydrogen and electricity.

The DOE laboratories, led by the INL, will perform R&D that will be critical to the success of the VHTR, primarily in the areas of high-temperature gas reactor fuels behavior, high-temperature materials qualification, design methods development and validation, hydrogen production technologies, and energy conversion.

The current R&D work is addressing fundamental issues that are relevant to a variety of possible VHTR designs. This section of the call describes the VHTR R&D planned and currently underway in the first three topic areas listed above. The work is being conducted in accordance with the document entitled "Next Generation Nuclear Plant – Research and Development Program Plan," INEEL/EXT-05-02581. The DOE-funded hydrogen production and energy conversion technologies programs are described elsewhere in this document.

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2.2 Sodium Fast Reactor: The sodium-cooled fast reactor (SFR) uses liquid sodium as the reactor coolant, allowing high power density at low coolant volume fraction. The primary system operates at near-atmospheric pressure with typical outlet temperatures of 500-550 degrees celcius; at these conditions, conventional steel structural materials can be utilized, and a large margin to coolant boiling is maintained. The reactor unit can be arranged in a pool layout or a compact loop layout. A variety of fuel options are being considered for the SFR including metal alloy, oxide, and nitride. Plant sizes ranging from small modular systems to large monolithic reactors are considered.

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The primary mission for the SFR is the effective management of high-level wastes and uranium resources. The transuranics (TRU), primarily Pu, Am, Np, and Cm, are the primary contributors to nuclear waste disposal challenges (e.g., long-term heat load, peak repository dose, and radiotoxicity). Thus, a critical goal of the Global Nuclear Energy Partnership (GNEP) advanced fuel cycle strategy is to exclude these materials from the final waste. The TRU are separated from spent fuel and recycled for transmutation into fission products with more amenable waste characteristics. This process is commonly called "actinide burning".

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In a fast spectrum, actinides are preferentially fissioned not transmuted into higher actinides. This implies that fast systems are more "efficient" in destroying actinides; and the generation rate of higher actinides is suppressed. Therefore, the SFR is the base technology for TRU recycle and destruction in the Advanced

Burner Reactor fuel cycle component of the GNEP. For this mission, a critical SFR issue is the development and demonstration of economic and proliferation-resistant recycle processes.

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With innovations to reduce capital cost and improve efficiency, the Generation IV SFR system promises to be a more attractive option for electricity production than previous and existing prototype sodium-cooled fast reactors. The Generation IV Technology Roadmap ranked the SFR highly for sustainability because the closed fuel cycle significantly improves the utilization of natural uranium. The SFR is also highly rated for safety performance. Bounding transient events are accommodated by inherent system responses and/or passive measures.

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The SFR has the highest technical maturity level among Generation IV systems; its development approach builds on technologies already developed and demonstrated for sodium-cooled reactors and associated fuel cycles in fast reactor programs worldwide. The majority of the R&D needs that remain for the SFR reactor technology are related to performance rather than viability of the system. The Generation IV SFR system research plan includes work on SFR design and safety, advanced fuels, and component design and balance-of-plant; some specific tasks are highlighted in Appendix I.

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2.3 Design and Evaluation Methods Development: The development of Generation IV systems requires modeling and simulation capabilities that provide accurate predictions of system performance. Viability of new technologies and design features will require confirmation by credible analyses verified with experimental data. The need to confirm performance advances relative to current generation systems creates a strong incentive to reduce modeling uncertainties that necessitate conservatism in design (which limit performance gains) or potentially costly efforts to improve upon the capabilities of available technologies. Credible analyses will also be required as the basis for regulatory reviews and licensing of Generation IV designs of choice.
The objectives of the Generation IV research on Design and Evaluation Methods (D&EM) are to:

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· Enable cost-effective verification of system viability and development of high-performance system designs by providing capabilities for system analysis, safety enhancement, and performance optimization.

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· Provide methodologies for measuring the performance of Generation IV systems against Generation IV technology goals.

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· Support R&D prioritization based on results of system design analyses and performance evaluations.

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· Form the groundwork for safety review, licensing and regulation of Generation IV systems.

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2.4 Crosscutting Materials Development for Advanced Reactors: An integrated R&D program will be conducted to study, quantify, and in some cases, develop materials with required properties for the Generation IV advanced reactor systems. The goal of the National Materials Program is to ensure that the required materials R&D will be a comprehensive and integrated effort to identify and provide the materials data and its interpretation needed for establishing the viability of concept, design, and construction of the advanced reactor concepts being pursued within DOE's Generation IV Program.

For the range of service conditions expected in Generation IV systems, including possible accident scenarios, sufficient data must be developed to demonstrate that the candidate materials meet the following design objectives; acceptable dimensional stability including void swelling, thermal creep, irradiation creep, stress relaxation, and growth; acceptable strength, ductility, and toughness; acceptable resistance to creep rupture, fatigue cracking, creep-fatigue interactions, and helium embrittlement; and acceptable chemical compatibility and corrosion resistance (including stress corrosion cracking and irradiation-assisted stress corrosion cracking) in the presence of coolants and process fluids.

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Additionally, it will be necessary to develop validated models of microstructure-property relationships to enable predictions of long-term materials behavior to be made with confidence and to develop high-temperature materials design methodology for materials, use, codification, and regulatory acceptance.

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2.5 Energy Conversion: Generation IV Energy Conversion work focuses development on more efficient or lower-cost electrical conversion technologies for the outlet temperature ranges of interest to Generation IV reactors. Generation IV reactor concepts will have higher output temperatures ranging from 400 to 500 C for the SCWR to up to 1000 C for the VHTR. For the fast reactors and the VHTR, brayton cycles using inert or other gas working fluids are promising technologies for these temperature ranges. Current R&D focuses on development of the supercritical-CO_2 cycle for the intermediate temperature systems (500 to 700 C) and helium brayton cycles for the high-temperature VHTR.

The supercritical-CO_2 cycle research includes turbomachinery design studies to understand any unique turbomachinery issues; power conversion system configuration and preliminary cost studies; system control studies to develop control approaches and understand stability issues; and an evaluation of small-scale experiments for demonstration of the key technologies. Supercritical-CO_2 work in the FY05 and FY06 will focus on the key viability issue of control system approach and stability.

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Energy Conversion activities for the high-temperature brayton systems focus on thermodynamic analyses and plant configuration studies to assess a range of options for improvements in cycle efficiency or conversion system cost. These analytical studies include evaluation of combined cycle configurations, interstage heating and cooling cycles, or other innovative cycle options to increase performance or reduce costs. The investigation of advanced power conversion options for Generation IV reactors will include scaled experiments to provide a validated technology basis for next-generation engineering decisions. Initial demonstrations will involve laboratory scale experiments for components and key technologies to validate viability and performance assessments

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3. Nuclear Hydrogen Initiative

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Projects proposed on these technologies should not duplicate research and development activities being pursued by the other DOE Hydrogen Program offices – Energy Efficiency and Renewable Energy, Fossil Energy, and Science. Information on the research being conducted by these offices can be found at http://www.hydrogen.energy.gov/.

Applications for Nuclear Hydrogen Initiative projects must define, to some level of detail, what steps will be taken to ensure safe handling, etc., and a commitment to provide a more detailed action plan within 60 days after award. This requirement is further defined in a Safety Requirements Document at http://www.eere.energy.gov/hydrogenandfuelcells/pdfs/safety_guidance.pdf).

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3.1 Thermochemical Cycles: DOE is investigating the use of thermochemical cycles for hydrogen production using high temperature advanced nuclear reactors. Thermochemical cycles involve a series of chemical reactions that produce hydrogen from water at lower temperatures than direct thermal dissociation of water. High temperature advanced reactors will provide the heat for the endothermic chemical reactions. This task area will focus on the development of thermochemical cycles suitable for coupling to a high temperature nuclear reactor. Analytic and lab scale experimental studies will be performed for the sulfur-iodine and hybrid sulfur cycles to evaluate cycle performance and viability for use with nuclear energy. Analytic studies will also investigate several promising alternative cycles that may have potential for use with nuclear reactors, and lab scale experimental work will be initiated where appropriate. Flowsheet analyses will be performed to identify promising approaches, and lab-scale experiments will confirm technical feasibility and performance potential. For the selected processes, pilot-scale systems will be constructed and operated in FY 2009 to demonstrate efficiency and performance, and engineering scale systems will subsequently be constructed to demonstrate economically viable hydrogen production using nuclear heat.

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3.2 High Temperature Electrolysis: This element of the Nuclear Hydrogen Initiative focuses on developing components and overall designs for splitting steam into hydrogen and oxygen using high-temperature solid-oxide electrolyzer cells (SOECs). The technology is derived from the materials and configurations now used in solid oxide fuel cells (SOFCs) in fossil-fired applications. At the 750-900 °C operating temperatures of SOECs, about 30% of the energy for electrolysis is supplied thermally, increasing the overall efficiency of the process to about 45%. The high-temperature electrolysis (HTE) project has conducted stack experiments using five to ten 10 x 10 cm cells in series to investigate the thermal and electrical performance of both the electrolyte and the interconnection plates. These stack experiments were performed in October 2004 and January 2005 and produced hydrogen in excess of 90 normal liters per hour. Tests at 50-60 normal liters per hour were conducted over durations of two weeks during each campaign. The tests being conducted this year will be of long duration to identify and understand mechanisms for cell degradation due to corrosion, creep and material transport in high temperature operation.

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In addition, the project is developing conceptual designs for the series of experiments needed to demonstrate the concept on a commercial scale when attached to a 600-MWth VHTR. Besides the cells themselves, this design activity is determining requirements for electrical power control, steam-hydrogen separations and hydrogen and oxygen cooling. Finally, the project is investigating methods for reducing the overall costs of hydrogen production through HTE. An engineering process model has been developed to investigate the behavior of a full-scale HTE plant under various operating conditions.

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3.3 Reactor-Hydrogen Production Process Interface: The System Interface and Support Systems activity consists of three interdependent areas of responsibility. These areas and their associated boundary assumptions are:

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1) Reactor/Process Interface – This task area concerns the development of all connections and interfaces that must be made to connect a high-temperature nuclear reactor to a hydrogen production plant. It is an area of critical importance to the development of nuclear hydrogen capabilities and is the primary focus of the Systems Interface research area in the near term. It also addresses the operational behavior of such a system, and includes efforts to understand and control potential negative impacts from system or component failures, control functions, or process feedback from one side of the interface to the other, and all work to control or eliminate those negative impacts. The key components in the reactor/process interface area are the high-temperature heat exchangers required to transport thermal energy from the nuclear plant to the hydrogen production plant. This area includes research and development of high temperature heat exchangers and materials of construction.

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2) Balance of Plant (BOP) – Balance of plant encompasses all components and systems of the hydrogen production plant that do not directly perform or support the chemical or electrolysis processes involved in generating hydrogen. Examples are heat exchangers that do not provide direct reaction heat, product and byproduct handling systems, waste handling systems, off-gas treatment, water treatment systems, and sampling systems. In general BOP includes all components and systems that are within the plant but are not primary components of the hydrogen generation process. BOP requirements may be highly dependent upon the specific hydrogen production process and operational

conditions.
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3) Process Infrastructure and Support Facilities – Process infrastructure includes physical space requirements, electrical, non-electrical energy sources, support laboratories, machine shop, spare parts stores, bulking facilities for feedstock, byproducts and waste materials. Infrastructure requirements tend not to be highly dependent upon specific processes other than capacity.
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The scope of the Systems Interface and Support Systems area is to ensure that all support systems and reactor interface issues and requirements are met and are ready to support the decision process as the different hydrogen generation processes mature towards the pilot and engineering scale decisions.
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Since this area became a distinct area of study under the DOE Nuclear Hydrogen Initiative in 2004, early work has made it clear that the largest technical issues and challenges lie in the development of the nuclear reactor/hydrogen process interface. Though there are challenges associated also with BOP and plant infrastructure, these will be pursued more vigorously at a later time, after the hydrogen production processes have reached a greater level of maturity.
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Research needs for the system interface are broadly divided into four areas: materials, mechanical construction, system interface operation, and safety.

PART II – AWARD INFORMATION

A. TYPE OF AWARD INSTRUMENT.
DOE anticipates awarding cooperative agreements under this program announcement (See Section VI.B.2 Statement of Substantial Involvement)

B. ESTIMATED FUNDING.
Approximately $ 4,000,000 is expected to be available for new awards under this announcement.

C. MAXIMUM AND MINIMUM AWARD SIZE
Ceiling (i.e., the maximum amount for an individual award made under this announcement): $250,000

Floor (i.e., the minimum amount for an individual award made under this announcement): None

D. EXPECTED NUMBER OF AWARDS.
DOE anticipates making approximately 15 -25 awards under this announcement.

E. ANTICIPATED AWARD SIZE
DOE expects to fund up to $200,000 per year for up to 3 years. If requested levels are higher, applicants must justify need for more funds consistent with the ceiling on individual awards described in paragraph C above.

F. PERIOD OF PERFORMANCE.
DOE anticipates making awards that will run for up to 3 years.

G. TYPE OF APPLICATION.
DOE will only accept applications for new awards under this solicitation.

PART III – ELIGIBILITY INFORMATION

A. ELIGIBLE APPLICANTS.
In accordance with 10 CFR 600.6(b), eligibility for award is restricted to U.S. Colleges and Universities. Furthermore, any proposed project involving use of the Advanced Test Reactor (ATR) for testing, experimentation, etc., all investigators for the project who would be working in the ATR must be U.S. Citizens.

B. COST SHARING.
The cost share must be at least 20% of the total allowable costs of the project (i.e., the sum of the Government share, including FFRDC contractor costs if applicable, and the recipient share of allowable costs equals the total allowable costs of the projects) and must come from non-Federal sources. (See 10 CFR part 600 for the applicable cost share requirements.)

C. OTHER ELIGIBILITY REQUIREMENTS.

FFRDC applicants are not eligible for an award under this announcement, but they may be proposed as a team member subject to the following guidelines:

Authorization for non-DOE/NNSA FFRDCs. The Federal agency sponsoring the FFRDC contractor must authorize in writing the use of the FFRDC contractor on the proposed project and this authorization must be submitted with the application. The use of a FFRDC contractor must be consistent with the contractor's authority under its award and must not place the FFRDC contractor in direct competition with the private sector.

Authorization for DOE/NNSA FFRDCs. The cognizant contracting officer for the FFRDC must authorize in writing the use of a DOE/NNSA FFRDC contractor on the proposed project and this authorization must be submitted with the application. The following wording is acceptable for this authorization.

> "Authorization is granted for the _____________ Laboratory to participate in the proposed project. The work proposed for the laboratory is consistent with or complimentary to the missions of the laboratory, will not adversely impact execution of the DOE/NNSA assigned programs at the laboratory, and will not place the laboratory in direct competition with the domestic private sector."

Value/Funding. The value of, and funding for, the FFRDC contractor portion of the work will not normally be included in the award to a successful applicant. Usually, DOE/NNSA will fund a DOE/NNSA FFRDC contractor through the DOE field work proposal system and other FFRDC contractors through an interagency agreement with the sponsoring agency.

Cost Share. The applicant's cost share requirement will be based on the total cost of the project, including the applicant's and the FFRDC contractor's portions of the effort.

FFRDC Contractor Effort:

> The FFRDC contractor effort, in aggregate, shall not exceed 20 % of the total estimated cost of the project, including the applicant's and the FFRDC contractor's portions of the effort.

Responsibility. The applicant, if successful, will be the responsible authority regarding the settlement and satisfaction of all contractual and administrative issues, including but not limited to, disputes and claims arising out of any agreement between the applicant and the FFRDC contractor.

PART IV – APPLICATION AND SUBMISSION INFORMATION

A. ADDRESS TO REQUEST APPLICATION PACKAGE.

Application forms and instructions are available at Grants.gov. To access these materials, go to http://www.grants.gov, select "Apply for Grants", and then select "Download Application Package". Enter the CFDA and/or the funding opportunity number located on the cover of this announcement and then follow the prompts to download the application package. NOTE: You will not be able to download the Application Package unless you have installed PureEdge Viewer (See: http://www.grants.gov/DownloadViewer).

B. LETTER OF INTENT AND PRE-APPLICATION.

1. Letter of Intent.

Applicants are requested to submit a letter of intent by June 12, 2006 this letter should include the name of the applicant, the title of the project, the name of the Project Director/Principal Investigator(s), the amount of funds requested, and a one-page abstract. Letters of intent will be used to organize and expedite the merit review process. Failure to submit such letters will not negatively effect a responsive application submitted in a timely fashion. The letter of intent should be sent by E-mail to Ronald.Fellows@Nuclear.Energy.Gov.

2. Pre-application.
Pre-applications are not required.

C. **CONTENT AND FORM OF APPLICATION – SF 424 (R&R)**

You must complete the mandatory forms and any applicable optional forms (e.g., SF-LLL- Disclosure of Lobbying Activities) in accordance with the instructions on the forms and the additional instructions below. **Files that are attached to the forms must be in Adobe Portable Document Format (PDF) unless otherwise specified in this announcement.**

1. SF 424 (R&R).
Complete this form first to populate data in other forms. Complete all the required fields in accordance with the pop-up instructions on the form. To activate the instructions, turn on the "Help Mode" (Icon with the pointer and question mark at the top of the form). The list of certifications and assurances referenced in Field 18 can be found on the Applicant and Recipient Page at http://grants.pr.doe.gov.

2. NA

3. RESEARCH AND RELATED Other Project Information.
Complete questions 1 through 5 and attach files. The files must comply with the following instructions:

Project Summary/Abstract (Field 6 on the Form)
The project summary/abstract must contain a summary of the proposed activity suitable for dissemination to the publication. It should be a self-contained document that identifies the name of the applicant, the project director/principal investigator(s), the project title, the objectives of the project, a description of the project, including methods to be employed, the potential impact of the project (i.e., benefits, outcomes), and major participants (for collaborative projects). This document must not include any proprietary or sensitive business information as the Department may make it available to the public. The project summary must not exceed 1 page when printed using standard 8.5" by 11" paper with 1" margins (top, bottom, left and right) with font not smaller than 11 point. To attach a Project Summary/Abstract, click "Add Attachment."

Project Narrative (Field 7 on the form)
The project narrative must not exceed 14 pages, including charts, graphs, maps, photographs, and other pictorial presentations, when printed using standard 8.5" by 11" paper with 1 inch margins (top, bottom, left, and right). EVALUATORS WILL ONLY REVIEW THE NUMBER OF PAGES SPECIFIED IN THE PRECEDING SENTENCE. The font must not be smaller than 11 point. Do not include any Internet addresses (URLs) that provide information necessary to review the application, because the information contained in these sites will not be reviewed. See Part VIII.D for instructions on how to mark proprietary application information. To attach a Project Narrative, click "Add Attachment."

The project narrative must include:

Project Objectives.
This section should provide a clear, concise statement of the specific objectives/aims of the proposed project.

Merit Review Criterion Discussion.
The section should be formatted to address each of the merit review criterion and sub-criterion listed in Section V. A. Provide sufficient information so that reviewers will be able to evaluate the application in accordance with these merit review criteria. DOE/NNSA WILL EVALUATE AND CONSIDER ONLY THOSE APPLICATIONS THAT ADDRESS SEPARATELY EACH OF THE MERIT REVIEW CRITERION AND SUB-CRITERION.

Project Timetable:
This section should outline as a function of time, year by year, all the important activities or phases of the project, including any activities planned beyond the project period. Successful applicants must use this project timetable to report progress.

Evaluation Phase:
This section must include a plan and metrics to be used to assess the success of the project.

Current and Pending Support. List all current and pending support. For each organization providing support, show the total award amount for the entire award period (including indirect costs) and the number of person-months per year to be devoted to the project. Concurrent submission of an application to other organizations for simultaneous consideration will not prejudice its review.

Identification of Potential Conflicts of Interest or Bias in Selection of Reviewers. Provide the following information in this section:

Collaborators and Co-editors: List in alphabetical order all persons, including their current organizational affiliation, who are, or who have been, collaborators or co-authors with you on a research project, book or book article, report, abstract, or paper during the 48 months preceding the submission of this application. Also, list any individuals who are currently, or have been, co-editors with you on a special issue of a journal, compendium, or conference proceedings during the 24 months preceding the submission of this application. If there are no collaborators or co-editors to report, state “None.”
Graduate and Postdoctoral Advisors and Advisees: List the names and current organizational affiliations of your graduate advisor(s) and principal postdoctoral sponsor(s) during the last 5 years. Also, list the names and current organizational affiliations of your graduate students and postdoctoral associates during the past 5 years.

Third Parties Contributing to Cost Sharing Appendix: At the time you submit your application, you must have a letter from each third party (i.e., a party other than the organization submitting the application) letter must state that the third party is committed to providing a specific minimum dollar amount of cost sharing. By submitting your application, you are providing assurance that you have signed letters of commitment. In an appendix to your Project Narrative, you must identify the following information for each third party contributing to cost sharing: (1) the name of the organization; (2) the proposed dollar amount to be provided; (3) the amount as a percentage of the total project cost; and (4) the proposed cost sharing – cash, services, or property. This appendix will not count in the project narrative page limitation. Successful applicants must provide the signed letters of commitments within the number of days specified in Part IV.D, Submissions from Successful Applicants.

Bibliography & References Cited (Field 8 on the form)
Provide a bibliography of any references cited in the Project Narrative. Each reference must include the names of all authors (in the same sequence in which they appear in the publication), the article and journal title, book title, volume number, page numbers, and year of publication. Include only bibliographic citations. Applicants should be especially careful to follow scholarly practices in providing citations for source materials relied upon when preparing any section of the application. In order to reduce the number of files attached to your application, please provide the Bibliography and References Cited information as an appendix to your project narrative. Do not attach a file in field 8. This appendix will not count in the project narrative page limitation.

Facilities & Other Resources (Field 9 on the form)
This information is used to assess the capability of the organizational resources, including subawardee resources, available to perform the effort proposed. Identify the facilities to be used (Laboratory, Animal, Computer, Office, Clinical and Other). If appropriate, indicate their capacities, pertinent capabilities, relative proximity, and extent of availability to the project. Describe only those resources that are directly applicable to the proposed work. Describe other resources available to the project (e.g., machine shop, electronic shop) and the extent to which they would be available to the project. In order to reduce the number of files attached to your application, please provide the Facility and Other Resource information as an appendix to your project narrative. Do not attach a file in field 9. This appendix will not count in the project narrative page limitation.

Equipment (Field 10 on the form)
List major items of equipment already available for this project and, if appropriate identify location and pertinent capabilities. In order to reduce the number of files attached to your application, please provide the Equipment information as an appendix to your project narrative. Do not attach a file in field 10. This appendix will not count in the project narrative page limitation.

Other Attachment (Field 11 on the form)
If you need to elaborate on your responses to questions 1-5 on the “Other Project Information” document, provide the information in a single file named “projinfo.pdf”. Click on “Add Attachments” in Field 11 to attach file.

Also, attach the following files:

Commitment Letters from Third Parties Contributing to Cost Sharing.
If a third party, (i.e., a party other than the organization submitting the application)

proposes to provide all or part of the required cost sharing, you must provide a letter from the third party stating that it is committed to providing a specific minimum dollar amount of cost sharing. The letter should also identify the proposed cost sharing (e.g., cash, services, and/or property) to be contributed. Letters must be signed by the person authorized to commit the expenditure of funds by the entity. Save this information in a single file named “CLTP.pdf” and click on “Add Attachments” in Field 11 to attach.

Budget for DOE/NNSA Federally Funded Research and Development Center (FFRDC) Contractor, if applicable.
If a DOE/NNSA FFRDC contractor is to perform a portion of the work, you must provide a DOE Field Work Proposal in accordance with the requirements in DOE Order 412.1 Work Authorization System. This order and the DOE Field Work Proposal form are available at http://grants.pr.doe.gov. Use up to 10 letters of the FFRDC name (plus .pdf) as the file name (e.g., lanl.pdf or anl.pdf), and click on “Add Attachments” in Field 11 to attach.

Project Management Plan
This plan should identify the activities/tasks to be performed, a time schedule for the accomplishment of the activities/tasks, the spending plan associated with the activities/tasks, and the expected dates for the release of outcomes. Applicants may use their own project management system to provide this information. This plan should identify any decision points and go/no-go decision criteria. Successful applicants must use this plan to report schedule and budget variances. Save this plan in a single file named “pmp.pdf” and click on “Add Attachments” in Field 11 to attach.

4. RESEARCH AND RELATED Senior/Key Person.
Complete this form before the Budget form to populate data on the Budget form. Beginning with the PD/PI, provide a profile for each senior/key person proposed. A senior/key person is any individual who contributes in a substantive, measurable way to the scientific/technical development or execution of the project, whether or not a salary is proposed for this individual. Subawardees and consultants must be included if they meet this definition. For each senior/key person provide:

Biographical Sketch.
Complete a biographical sketch for each senior/key person and attach to the “Attach Biographical Sketch” field in each profile. The biographical information for each person must not exceed 2 pages when printed on 8.5” by 11” paper with 1 inch margins (top, bottom, left, and right) with font not smaller than 11 point and must include:

Education and Training. Undergraduate, graduate and postdoctoral training, provide institution, major/area, degree and year.

Research and Professional Experience: Beginning with the current position list, in chronological order, professional/academic positions with a brief description.

Publications. Provide a list of up to 10 publications most closely related to the proposed project. For each publication, identify the names of all authors (in the same sequence in which they appear in the publication), the article title, book or journal title, volume number, page numbers, year of publication, and website address if available electronically.

Patents, copyrights and software systems developed may be provided in addition to or substituted for publications.

Synergistic Activities. List no more than 5 professional and scholarly activities related to the effort proposed.

Current and Pending Support.
Current and pending support information is not required for this program. Do not attach a Current and Pending Support file.

5. RESEARCH AND RELATED BUDGET (TOTAL FED + NON-FED).
Complete the Research and Related Budget form in accordance with the instructions on the form (Activate Help Mode to see instructions) and the following instructions. You must complete a separate budget for each year of support requested. The form will generate a cumulative budget for the total project period. You must complete all the mandatory information on the form before the NEXT PERIOD button is activated. You may request funds under any of the categories listed as long as the item and amount are necessary to perform the proposed work, meet all the criteria for allowability under the applicable Federal cost principles, and are not prohibited by the funding restrictions in this announcement (See PART IV, G).

Budget Justification (Field K on the form).
Provide the required supporting information for the following costs (See R&R Budget instructions): equipment; domestic and foreign travel; participant/trainees; material and supplies; publication; consultant services; ADP/computer services; subaward/consortium/contractual; equipment or facility rental/user fees; alterations and renovations; and indirect cost type. Provide any other information you wish to submit to justify your budget request. If cost sharing is required, provide an explanation of the source, nature, amount and availability of any proposed cost sharing. Attach a single budget justification file for the entire project period in Field K. The file automatically carries over to each budget year.

6. R&R SUBAWARD (FED/NON-FED) BUDGET ATTACHMENT(S) FORM.
Budgets for Subawardees, other than DOE FFRDC Contractors. You must provide a separate cumulative R&R budget for each subawardee that is expected to perform work estimated to be more than $100,000 or 50 percent of the total work effort (whichever is less). If you are selected for award, you must submit a multi-year budget for each of these subawardee (See Section IV.D for submission of Subawardees' multi-year budgets). Download the R&R Budget Attachment from the R&R SUBAWARD BUDGET ATTACHMENT(S) FORM and e-mail it to each subawardee that is required to submit a separate budget. Note: Subwardees must have installed PureEdge Viewer before they can complete the form. After the Subawardee has e-mailed its completed budget back to you, attach it to one of the blocks provided on the form. Use up to 10 letters of the subawardee's name (plus .xfd) as the file name (e.g., ucla.xfd or energyres.xfd).

7. SF-LLL Disclosure of Lobbying Activities
If applicable, complete SF- LLL. Applicability: If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the grant/cooperative agreement, you must complete and submit Standard Form - LLL, "Disclosure Form to Report Lobbying."

D. **SUBMISSIONS FROM SUCCESSFUL APPLICANTS**.
Successful applicants must submit the information listed below not later than 10 calendars days after notification of selection. Applicants who fail to provide the information within the required time period may be eliminated from further consideration.
Environmental Checklist, Point of Contact Checklist

What to submit	Required Form or Format
Designated Responsible Employee for complying with national policies prohibiting discrimination. Provide organization name, project title, DOE application tracking number and the name, title, and phone number of Designated Responsible Employee for complying with national policies prohibiting discrimination (See 10 CFR 1040.5)	No special format. E-mail information to: fellowrg@id.doe.gov
Representation of Limited Rights Data and Restricted Software.	Use form on Applicant and Recipient Page at http://grants.pr.doe.gov. Send this representation to: fellowrg@id.doe.gov
Environmental Questionnaire. You must complete and submit an environmental questionnaire.	http://www.id.doe.gov/doeid/PSD/proc-div.html

E. SUBMISSION DATES AND TIMES

1. Pre-application Due Date.

Pre-applications are not required.

2. Application Due Date.

Applications should be received by 06/28 2006 not later than 8:00 PM Eastern Time. You are encouraged to transmit your application well before the deadline. APPLICATIONS RECEIVED AFTER THE DEADLINE WILL NOT BE REVIEWED OR CONSIDERED FOR AWARD.

F. GOVERNMENTAL REVIEW

This program is not subject to Executive Order 12372 – Intergovernmental Review of Federal Programs.

G. FUNDING RESTRICTIONS.

Cost Principles. Costs must be allowable in accordance with the applicable Federal cost principles referenced in 10 CFR part 600.

Pre-award Costs. Recipients may charge to an award resulting from this announcement pre-award costs that were incurred within the ninety (90) calendar day period immediately preceding the effective date of the award, if the costs are allowable in accordance with the applicable Federal cost principles referenced in 10 CFR part 600. Recipients must obtain the prior approval of the contracting officer for any pre-award costs that are for periods greater than this 90 day calendar period.

Pre-award costs are incurred at the applicant's risk. DOE is under no obligation to reimburse such costs if for any reason the applicant does not receive an award or if the award is made for a lesser amount than the applicant expected.

H. OTHER SUBMISSION AND REGISTRATION REQUIREMENTS

1. Where to Submit.

APPLICATIONS MUST BE SUBMITTED THROUGH GRANTS.GOV TO BE CONSIDERED FOR AWARD. Submit electronic applications through the “Apply for Grants” function at www.Grants.gov. If you have problems completing the registration process or submitting your application, call Grants.gov at 1-800-518-4726 or send an email to support@grants.gov.

2. Registration Process.

You must COMPLETE the one-time registration process (all steps) before you can submit your first application through Grants.gov (See www.grants.gov/GetStarted). **We recommend that you start this process at least two weeks before the application due date.** It may take 14 days or more to complete the entire process. Use the Grants.gov Organizational Registration Checklists at http://www.grants.gov/assets/OrganizationRegCheck.doc to guide you through the process. IMPORTANT: During the CCR registration process, you will be asked to designate an E-Business Point of Contact (EBIZ POC). The EBIZ POC must obtain a special password called “Marketing Partner identification Number” (MPIN).

Part V - APPLICATION REVIEW INFORMATION

A. CRITERIA

1. Initial Review Criteria.
Prior to a comprehensive merit evaluation, DOE will perform an initial review to determine that (1) the applicant is eligible for an award; (2) the information required by the announcement has been submitted; (3) all mandatory requirements are satisfied; and (4) the proposed project is responsive to the objectives of the funding opportunity announcement.

2. Merit Review Criteria.
1. Technical quality of the proposed work (40%).
.
a. Contribution to the state of knowledge in the relevant program element and applicable scope;
.
b. Completeness and clarity of the technical application;
.
c. Appropriateness/adequacy of the proposed methodology or approach;
.
2. Significance and Impact (30%), Significance of the proposed application vs. current practices. This significance assessment will consider: understanding of deficiencies of current practices and feasibility of an applicant’s technology to overcome the deficiencies; and benefits in terms of anticipated performance improvements (technical, operational, and environmental aspects) and cost savings of the proposed application over current practices.
.
3. Principal Investigator (30%). Capabilities and qualifications of principal investigator/project manager and key personnel; adequacy of resources and facilities applied by participating organization; and timeliness of report submittal on past projects.

3. Other Selection Factors.
1. Balanced portfolio of projects that represent a diversity of technologies and proposing entities.
.

2. Past performance of the University in regards to the timeliness of report submittals.

.

These factors, collectively the "Program Policy Factors" while not indicators of the Application's merit, e.g., technical excellence, applicant's ability, etc., may be essential to the process of selecting the application(s) that, individually or collectively, will best achieve the program objectives. Such factors are often beyond the control of the Applicant.

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Each Applicant should recognize that some very good applications might not receive an award because they do not fit within a mix of projects that maximizes the probability of achieving the DOE's overall research and development objectives. Therefore, the Program Policy Factors may be used by the Selection Official to assist in determining which of the ranked application(s) shall receive DOE funding support.

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The Program Policy factors will be independently considered by the Selection Official in determining the optimum mix of applications that will be selected for support.

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These policy factors will provide the Selection Official with the capability of developing, from the competitive solicitation, a broad involvement of organizations and organizational ideas, which both enhance the overall technology research effort and upgrade the program content to meet the goals of the DOE

B. REVIEW AND SELECTION PROCESS.

1. Merit Review.

Applications that pass the initial review will be subjected to a merit review in accordance with the guidance provided in the "Department of Energy Merit Review Guide for Financial Assistance and Unsolicited Proposals." This guide is available under Financial Assistance, Regulations and Guidance at http://professionals.pr.doe.gov/ma5/ma-5web.nsf/?Open.

2. Selection.

The Selection Official will consider the merit review recommendation, program policy factors, and the amount of funds available.

3. Discussions and Award.

The Government may enter into discussions with a selected applicant for any reason deemed necessary, including but not limited to: (1) the budget is not appropriate or reasonable for the requirement; (2) only a portion of the application is selected for award; (3) the Government needs additional information to determine that the recipient is capable of complying with the requirements in 10 CFR part 600; and/or (4) special terms and conditions are required. Failure to resolve satisfactorily the issues identified by the Government will preclude award to the applicant.

C. ANTICIPATED NOTICE OF SELECTION AND AWARD DATES.

DOE anticipates notifying applicants selected for award by 09/18/2006 and making awards by 01/15/2007.

Part VI - AWARD ADMINISTRATION INFORMATION

A. AWARD NOTICES.

1. Notice of Selection.

DOE will notify applicants selected for award. This notice of selection is not an authorization to begin performance. (See Part IV.G with respect to the allowability of pre-award costs.)

Organizations whose applications have not been selected will be advised as promptly as possible. This notice will explain why the application was not selected.

2. Notice of Award.

A Notice of Financial Assistance Award issued by the contracting officer is the authorizing award document. It normally includes, either as an attachment or by reference: 1. Special Terms and Conditions; 2. Applicable program regulations, if any; 3. Application as approved by DOE.; 4. DOE assistance regulations at 10 CFR part 600, or, for Federal Demonstration Partnership (FDP) institutions, the FDP terms and conditions; 5. National Policy Assurances To Be Incorporated As Award Terms; 6. Budget Summary; and 7. Federal Assistance Reporting Checklist, which identifies the reporting requirements.

B. ADMINISTRATIVE AND NATIONAL POLICY REQUIREMENTS.

1. Administrative Requirements.

The administrative requirements for DOE grants and cooperative agreements are contained in 10 CFR part 600 (See: http://ecfr.gpoaccess.gov), except for grants made to Federal Demonstration Partnership (FDP) institutions. The FDP terms and conditions and DOE FDP agency specific terms and conditions are located on the National Science Foundation web site at http://www.nsf.gov/awards/managing/fed_dem_part.jsp.

2. Special Terms and Conditions and National Policy Requirements.

Special Terms and Conditions and National Policy Requirements.
The DOE Special Terms and Conditions for Use in Most Grants and Cooperative Agreements are located at http://grants.pr.doe.gov. The National Policy AssurancesTo Be Incorporated As Award Terms are located at http://grants.pr.doe.gov.

Intellectual Property Provisions.
The standard DOE financial assistance intellectual property provisions applicable to the various types of recipients are located at http://www.gc.doe.gov/techtrans/sipp_matrix.html.

Statement of Substantial Involvement.
1 Statement of Substantial Involvement.

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DOE anticipates having substantial involvement during the project period, through technical assistance, advice, intervention, integration with other awardees performing related activities, and technology transfer activities.

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The recipient's responsibilities are listed in paragraph A and the DOE's responsibilities are listed in paragraph B.

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A. The recipient is responsible for:

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1. Performing the activities supported by this award, including providing the required personnel, facilities, equipment, supplies and services.

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2. Defining approaches and plans, submitting the plans to DOE for review, and incorporating DOE comments.

.

3. Managing and conducting the project activities, including coordinating with DOE and DOE contractors on activities related to the project.

.

4. Attending semi-annual program review meetings and reporting project status.

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5. Submitting technical reports to the DOE Program Director and incorporating DOE comments and:

.

6. Presenting the projects' results at appropriate technical conferences or meetings as directed by the DOE Program Director (number of conferences/meetings will not exceed 2 per year, not counting program review meetings.)

B. DOE is responsible for:

.

1. Reviewing in a timely manner project plans, including technology transfer plans, and redirecting the work effort if the plans do not address critical programmatic issues.

.

2. Conducting semi-annual program review meetings to ensure adequate progress and that the work accomplishes the program and project objectives. Redirecting work or shifting work emphasis, if needed.

.

3. Promoting and facilitating technology transfer activities, including dissiminating program results through presentations and publications.

.

4. Serving as scientific/technical liaison between awardees and other program or industry staff.

C. REPORTING.

Reporting requirements are identified on the Federal Assistance Reporting Checklist, DOE F 4600.2, attached to the award agreement. See N/A for the proposed Checklist for this program**.**

PART VII - QUESTIONS/AGENCY CONTACTS

A. QUESTIONS

Questions regarding the content of the announcement must be submitted through the "Submit Question" feature of the DOE Industry Interactive Procurement System (IIPS) at http://e-center.doe.gov. Locate the program announcement on IIPS and then click on the "Submit Question" button. Enter required information. You will receive an electronic notification that your question has been answered. DOE will try to respond to a question within 3 business days, unless a similar question and answer have already been posted on the website

Questions relating to the registration process, system requirements, how an application form works, or the submittal process must be directed to Grants.gov at 1-800-518-4726 or support@grants.gov. DOE cannot answer these questions.

Questions regarding program requirements must be directed to:

See instructions above for submitting questions on iips.

B. **Agency Contact**

Name:
Ron Fellows

E-mail address:
Ronald.Fellows@Nuclear.Energy.Gov

Fax:
208-526-5548

Telephone:

PART VIII - OTHER INFORMATION

A. **MODIFICATIONS.**

Notices of any modifications to this announcement will be posted on Grants.gov and the DOE Industry Interactive Procurement System (IIPS). You can receive an email when a modification or an announcement message is posted by joining the mailing list for this announcement through the link in IIPS. When you download the application at Grants.gov, you can also register to receive notifications of changes through Grants.gov.

B. **GOVERNMENT RIGHT TO REJECT OR NEGOTIATE.**

DOE reserves the right, without qualification, to reject any or all applications received in response to this announcement and to select any application, in whole or in part, as a basis for negotiation and/or award.

C. **COMMITMENT OF PUBLIC FUNDS.**

The Contracting Officer is the only individual who can make awards or commit the Government to the expenditure of public funds. A commitment by other than the Contracting Officer, either explicit or implied, is invalid.

D. **PROPRIETARY APPLICATION INFORMATION.**

Patentable ideas, trade secrets, proprietary or confidentional commercial or financial information, disclosure of which may harm the applicant, should be included in an application only when such information is necessary to convey an understanding of the proposed project. The use and disclosure of such data may be restricted, provided the applicant includes the following legend on the first page of the project narrative and specifies the pages of the application which are to be restricted:

“The data contained in pages _____ of this application have been submitted in confidence and contain trade secrets or proprietary information, and such data shall be used or disclosed only for evaluation purposes, provided that if this applicant receives an award as a result of or in connection with the submission of this application, DOE shall have the right to use or disclose the data herein to the extent provided in the award. This restriction does not limit the government's right to use or disclose data obtained without restriction from any source, including the applicant."

To protect such data, each line or paragraph on the pages containing such data must be specifically identified and marked with a legend similar to the following:

"The following contains proprietary information that (name of applicant) requests not be released to persons outside the Government, except for purposes of review and evaluation."

E. **EVALUATION AND ADMINISTRATION BY NON-FEDERAL PERSONNEL.**
In conducting the merit review evaluation, the Government may seek the advice of qualified non-Federal personnel as reviewers. The Government may also use non-Federal personnel to conduct routine, nondiscretionary administrative activities. The applicant, by submitting its application, consents to the use of non-Federal reviewers/administrators. Non-Federal reviewers must sign conflict of interest and non-disclosure agreements prior to reviewing an application. Non-Federal personnel conducting administrative activities must sign a non-disclosure agreement.

F. **INTELLECTUAL PROPERTY DEVELOPED UNDER THIS PROGRAM.**
Patent Rights. The government will have certain statutory rights in an invention that is conceived or first actually reduced to practice under a DOE award. 42 U.S.C. 5908 provides that title to such inventions vests in the United States, except where 35 U.S.C. 202 provides otherwise for nonprofit organizations or small business firms. However, the Secretary of Energy may waive all or any part of the rights of the United States subject to certain conditions. (See "Notice of Right to Request Patent Waiver" in paragraph G below.)

Rights in Technical Data. Normally, the government has unlimited rights in technical data created under a DOE agreement. Delivery or third party licensing of proprietary software or data developed solely at private expense will not normally be required except as specifically negotiated in a particular agreement to satisfy DOE's own needs or to insure the commercialization of technology developed under a DOE agreement.

Special Protected Data Statutes. This program is covered by a special protected data statute. The provisions of the statute provide for the protection from public disclosure, for a period of up to years from the development of the information, of data that would be trade secret, or commercial or financial information that is privileged or confidential, if the information had been obtained from a non-Federal party. Generally, the provision entitled, Rights in Data Programs Covered Under Special Protected Data Statutes, (10 CFR 600 Appendix A to Subpart D), would apply to an award made under this announcement. This provision will identify data or categories of data first produced in the performance of the award that will be made available to the public, notwithstanding the statutory authority to withhold data from public dissemination, and will also identify data that will be recognized by the parties as protected data.

G. **NOTICE OF RIGHT TO REQUEST PATENT WAIVER.**
Applicants may request a waiver of all or any part of the rights of the United States in inventions conceived or first actually reduced to practice in

performance of an agreement as a result of this announcement, in advance of or within 30 days after the effective date of the award. Even if such advance waiver is not requested or the request is denied, the recipient will have a continuing right under the award to request a waiver of the rights of the United States in identified inventions, i.e., individual inventions conceived or first actually reduced to practice in performance of the award. Any patent waiver that may be granted is subject to certain terms and conditions in 10 CFR 784.

Domestic small businesses and domestic nonprofit organizations will receive the patent rights clause at 37 CFR 401.14, i.e., the implementation of the Bayh-Dole Act. This clause permits domestic small business and domestic nonprofit organizations to retain title to subject inventions. Therefore, small businesses and nonprofit organizations do not need to request a waiver.

H. NOTICE REGARDING ELIGIBLE/INELIGIBLE ACTIVITIES.

Eligible activities under this program include those which describe and promote the understanding of scientific and technical aspects of specific energy technologies, but not those which encourage or support political activities such as the collection and dissemination of information related to potential, planned or pending legislation.

I. REFERENCE MATERIAL

APPENDIX I

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Detailed Project Objective in the Program Elements

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Proposed projects may involve work in any activity of these program elements. Some examples of specific current research needs of interest to each program elements are listed below. However, proposals are encouraged beyond the listed R&D topics so long as they are relevant to the goals of the Advanced Fuel Cycle R&D Program, the Generation IV Nuclear Energy Systems Initiative, or the Nuclear Hydrogen Initiative.

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All AGR TRISO fuel work is located in Generation IV, Section 2.1, VHTR

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1. Advanced Fuel Cycle R&D Program

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1.1 Spent Fuel Separations Technology

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The listing of some R&D needs below is organized according to programmatic activity categories. Other proposals in the general area of spent fuel separation technology would be welcome.

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Advanced Aqueous Separations

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· Evaluate the chemistry of transuranic element extraction in the UREX+ suite of aqueous solvent extraction processes.

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· Develop a process for the conversion of technetium strip solution from the UREX+ processes to metallic form for incorporation in a metallic waste form.

.

· Model and design organic extractants having acceptable radiation stability that can be used in a one-step separation of:

.

- Neptunium, plutonium, americium and curium from lanthanide fission products with a decontamination factor >104.

.

- Americium from curium, after lanthanide removal, with a decontamination factor >104.

.

· Synthesize stable advanced extractant solvent molecules with high specificity for minor actinides (Np,

Am, Cm).
.
Pyrochemical Processing
.
· Develop corrosion-resistant stable materials for use in process vessels and crucibles for containment of
.
(1) molten salts containing actinides and fission products,
.
(2) molten actinide metals and chloride salts, and; molten non-actinide metals including zirconium.
.
· Analyze the effects of small additions of common anions (Br-, F-, PO43-, I-) to molten chloride salts for use in electrochemical recovery of specific transuranic elements.
.
· Develop a durable anode material for use in electrochemical reduction of actinide oxides at temperatures of 650-750C
.
Engineered Product Storage
.
· Measure the thermal properties of the neptunium/ plutonium/ americium/curium oxide powder storage form with and without the presence of lanthanide fission products.
.
· Develop durable waste forms, fabricated at low cost, for the geologic disposal of iodine and tritium.
.
· Develop a concept of a storage form for the UREX+1 combined transuranic/lanthanide product stream and perform an evaluation of possible inexpensive container designs for temporary storage of this form.
.
· Assess the feasibility of incorporating the fission products barium, yttrium and rubidium in the steam reforming process for the production of the cesium/strontium storage form; measure the thermal properties of a prototype waste form comprised of non-radioactive constituents.
.
Spent Fuel Treatment Facility Design/Process Technology Development
.
· Develop a comprehensive plant operations simulation code for evaluation of process technology options prior to the pre-conceptual design of a large (2500 tonne/yr) spent fuel treatment facility. The code must provide for plant design parameter variation studies and produce a complete mass balance evaluation of all process streams for the chosen flowsheet and process technology. The code must also include provisions for the evaluation of process control, monitoring, and materials accountancy needs. Advanced graphical representations of processes and process equipment must be provided for maximum user benefit.
.
· Develop and demonstrate advanced on-line, near real-time analytical instrumentation for use in rapid and precise analysis of process streams, with the intention of providing a state-of-the-art system for the monitoring and control of process operations and the accounting of actinide materials for safeguards purposes.

1.2. Advanced Nuclear Fuel Development
.
The listing of some R&D needs below is organized according to programmatic activity categories.
Fuel design and analyses for advanced reactor concepts
.
· Define and analyze the fuel forms needed for transmuters (with high TRU content, high helium generation, high burnup objectives). Considerations such as strategically located burnable poisons and special getter materials in or around the fuel could be included. A proposal along these lines should include thermal and structural analyses for both normal operating conditions and accident conditions.
.
Fuel Performance
.
· Design phenomenological experiments (in reactor or out of reactor with neutron sources or ion beams) aimed at fundamental understanding of fuel performance. These activities should be aimed at designing small, simple, and shorter experiments that investigate fundamental aspects of radiation damage, amorphization, fuel restructuring, species diffusion, etc. Advanced on line instrumentation and characterization techniques also are included in this category.
.
Fuel safety envelope assessments
.
· Assess the safety envelopes of advanced fuel systems by analytical means. This should include

identifying the key phenomenology for establishing the safety envelope, designing specific transient tests to address the important phenomenology, and performing some of the out of pile tests.

.

Assessment of surrogate materials

.

· Determine appropriate surrogate materials for addressing different fuels phenomenology as an early way to avoid using expensive and time-consuming real materials. This should include process development using surrogate materials and correlation of the surrogate-based processes with a limited number of actual material based processes (to be supplied by the National Laboratories). This project should include the definition and quantification of how surrogate materials could be effectively employed to accelerate in-pile or out-of-pile testing of specific phenomenology.

.

Fabrication process development.

.

· Devise low-temperature or low-heat fuel fabrication process, specifically for Am-bearing fuels. Because of the high vapor pressure of Americium at typical sintering temperatures and during typical sintering times, a considerable fraction of the Am may be lost out of the fuel pellet. Either low temperature or high-temperature short duration sintering processes that meet the density and microstructure requirements must be developed. Laboratory testing of innovative processes can be carried out using thermodynamic surrogates (e.g., dysprosium).

.

· Devise remote fabrication and quality assurance processes for fuels containing high quantities of TRU. Fuels containing high-quantities of transuranics require remote fabrication and characterization. Innovative design concepts that minimize the cost of fabrication minimize the waste/scrap generation and that meet the quality assurance requirements with high reliability are of considerable interest.

.

· Devise fuel fabrication processes and benchmark the modeling processes against known data. Process models that minimize the testing and that can be used for optimization are important for the program. The research may also include a semi-empirical set of correlations between the fabrication process parameters and fuel irradiation performance results.

.

Advanced mechanistic models and simulation tools.

.

· Develop atomistic-scale to continuum scale models to replace the empirical modules in existing performance codes (e.g., FRAPCON for oxide fuels, PARFUME for TRISO fuels). Fuel development and qualification is an expensive process if one relies solely on testing and empirical knowledge. An important objective of the Advanced Fuel Cycle R&D Program is to enhance the capabilities of the fuel performance codes by replacing some of the empirical models with more mechanistic models based on first principles. The development of such models and benchmarking against available separate effect and integral effect data would be valuable. Models applicable to ceramic, metal and composite fuels are all within the scope of the ongoing research.

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1.3 Transmutation Engineering Technologies

.

The listing of some R&D needs below is organized according to programmatic activity categories.

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Physics

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· Produce an evaluated radiation damage cross-section library for use in calculating radiation damage parameters in spallation source environments.

.

· Perform analysis of new nuclear data taken for actinide isotopes.

.

· Evaluate new material assay techniques and establish nuclear data needs.

.

· Perform analyses of critical safe configurations for TRU fuels and separated process streams; establish uncertainties and nuclear data needs.

Materials for Transmutation Systems

.

· Evaluate austenitic (316L/D9) and ferritic/martensitic (HT-9) steels with additional silicon content.

·· Conduct advanced materials screening (refractory metals and alloys, ceramics and composites) for high performance systems (e.g. determine availability, fabrication processes, joint techniques, and thermal-mechanical properties in a non-radiation environment).

.
· Determine structural properties of potential structural and fuels materials as a function of radiation damage, helium production, and hydrogen production at temperatures of potential interest for advanced transmuter applications.

.
· Develop atomic-scale radiation damage models for extrapolating structural properties of potential structural and fuels materials.

.
· Develop and test new radiation damage resistant alloy formulations.

.
· Measure the fatigue or fatigue crack growth resistance of ferritic/martensitic alloys at prototypic temperatures of 400-600 C.

.
· Determine the applicability of nanostructured materials to radiation resistant applications. Determine the microstructural stability at prototypic temperatures of 400-600C.

.
· Determine the effect of single crystal orientation on radiation damage in BCC iron.

.
· Model the effects of irradiation in a high-energy proton and neutron spectrum (spallation and fast reactor conditions) on the mechanical properties of ferritic/martensitic steels at prototypic temperatures from 400-600C.

.
1.4 Advanced Fuel Cycle Systems Analysis

.
· The primary driver for repository design is long-term decay heat from Am-241. Aged spent fuel contains more Am-241 due to Pu-241 decay. Fresh spent fuel is too hot to transport and reprocess efficiently. An assessment of the optimal age for spent fuel recycling should include consideration of storage costs, DOT requirements, and a range of burn-up levels.

.
· One possible method to manage short-term repository heat load is removal of Cs and Sr from the HLW stream, diverting these fission products to separate decay storage. An assessment of waste forms, packaging, and decay storage designs for Cs and Sr for a minimum of 300 years is desired.

.
· Destruction of Am and potentially Cm is desired to reduce repository heat load and radiotoxicity. An assessment of fast reactor concepts for management of Am and Cm is desired, including practical target designs, associated core designs, residence time to achieve destruction, and optimal loadings to minimize the number of fast reactors needed.

.
· Fast reactors may be employed for both resource management and waste management. Design of flexible conversion ratio systems is of interest for time dependent management of both fissile inventories and higher actinides.

.
· A full closed fuel cycle would likely include removal of uranium, transuranics, and selected fission products (Cs/Sr and possibly I/Tc) from the HLW stream. The HLW with the remaining fission products would have considerably reduced volume and mass and lower decay heat output unless it was concentrated. An assessment of the degree of concentration possible is desired for different HLW forms and packaging approaches. The assessment should yield linear decay heat loads comparable to that expected using the planned repository SNF disposal packaging, while also assessing changes in waste package size and weight and shipping and shielding requirements.

.
· Several studies of market economics for nuclear reactors versus other energy sources have been performed in the recent past using historic fuel costs and interest rates. Recent market changes have reduced the utility of these studies. Updated studies are desired that include sensitivity analyses for a range of fuel costs, as well as consideration of impacts of current and proposed legislation.

.
· No large-scale remote operation nuclear facilities have been constructed in the U.S. in several years. Cost estimates for new reprocessing and remote fuel fabrication facilities can be based on historic designs. However, advances in robotics, materials, chemical separations equipment, sensors, control systems and construction practices may lower costs while regulatory changes may increase costs. An assessment of facility cost changes given current technologies, practices and regulations is desired.

.
· Deployment of advanced nuclear technology will depend in part on the societal understanding of nuclear energy cost/benefit/risk relative to other energy systems. Methods for comparison of dissimilar energy systems will be needed.

.
· Direct collaboration on existing systems codes and models is invited, both to examine new approaches

and sub-models while also helping to validate existing codes and models. Systems models are used to dynamically assess the complete fuel cycle over the next century. They use existing inventory information and separately developed reactor physics calculations as inputs to determine system level material flows and transmutation impacts on waste management, non-proliferation, resource utilization and economic objectives.

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2. Generation IV Nuclear Energy Systems Initiative

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2.1 Very-High-Temperature Reactor

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The listing of R&D needs below is organized according to programmatic activity categories.

Advanced Gas Reactor Fuel Development and Qualification

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Development and qualification of TRISO-coated low-enriched uranium fuel is a key R&D activity associated with the VHTR Program. The AGR Program includes work on improving the kernel fabrication, coating, and compacting technologies, irradiation and accident testing of fuel specimens, and fuel performance and fission product transport modeling. The primary goal of these activities is to successfully demonstrate that TRISO-coated fuel can be fabricated to withstand the high temperatures, burnup, and power density requirements of a prismatic block type VHTR with an acceptable failure fraction. It is assumed that TRISO fuel that is successful in a block reactor will also be successful in pebble-bed reactors since the particle packing fraction and the fuel temperatures are somewhat lower in pebble-bed reactors than in block reactors. In addition, commercialization of the fuel fabrication process, to achieve a cost-competitive fuel manufacturing capability that will reduce entry-level risks, is an important goal of the project.

An underlying theme for the VHTR/AGR fuel development and qualification work is the need to develop a more complete fundamental understanding of the relationship between the fuel fabrication process, key fuel properties, irradiation performance of the fuel, and release and transport of fission products in the VHTR primary coolant system. Fuel performance modeling and analysis of the fission product behavior in the primary circuit are important aspects of this work. Performance models are considered essential for several reasons, including guidance for the plant designer in establishing the core design and operating limits, and demonstrating to the licensing authority that the applicant has thorough understanding of the in-service behavior of the fuel system.

The AGR fuel development and qualification program consists of five elements: fuel manufacture, fuel and materials irradiations, post-irradiation examination and safety testing, fuel performance modeling, and fission product transport and source term modeling. Each task is discussed in some more detail below:

· Fuel Manufacture. The Fuel Manufacture task will produce coated-particle fuel that meets fuel performance specifications. This task also includes process development for kernels, coatings, and compacting; quality control (QC) methods development; scale-up analyses; and process documentation needed for technology transfer. Fuel and material samples will be fabricated for characterization, irradiation, and accident testing as necessary to meet the overall goals. Automated fuel fabrication technologies suitable for mass production of coated-particle fuel at an acceptable cost will also be developed. That work will be conducted during the later stages of the program in conjunction with a cosponsoring industrial partner.

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· Fuels and Materials Irradiation. The fuel and materials irradiation activities will provide data on fuel performance under irradiation as necessary to support fuel process development, to qualify fuel for normal operation conditions, and to support development and validation of fuel performance and fission product transport models and codes. It will also provide irradiated fuel and materials as necessary for post-irradiation examination and safety testing. A total of eight irradiation capsules have been defined to provide the necessary data and sample materials. The fuel irradiations will be conducted in the Advanced Test Reactor (ATR) located at the INL.

.

· Safety Testing And Post-Irradiation Examination. This task element will provide the equipment and processes to measure the performance of AGR fuel under accident conditions. This work will support the fuel manufacture effort by providing feedback on the accident-related performance of kernels, coatings, and compacts. Data from the post-irradiation examinations and accident testing will supplement the in-reactor measurements [primarily fission gas release-to-birth (R/B)] as necessary to demonstrate compliance with fuel performance requirements and support the development and validation of computer codes.

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· Fuel Performance Modeling. The fuel performance modeling will address the structural, thermal, and chemical processes that can lead to coated-particle failures. The release of fission products from the fuel particle will also be modeled, including the effects of fission product chemical interactions with the coatings, which can lead to degradation of the coated-particle properties. Computer codes and models will be further developed and validated as necessary to support fuel fabrication process development. Results of these modeling activities will be essential to the plant designer in establishing the core design and operation limits, and demonstration to the licensing authority that the applicant has a thorough understanding of the in-service behavior of the fuel system.

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· Fission Product Transport and Source Term Modeling. This task will address the transport of fission products produced within the coated particles and the fuel element to provide a technical basis for source terms for AGRs under normal and accident conditions. The technical basis will be codified in design methods (computer models) validated by experimental data. This information will provide the primary source term data needed for licensing.

Proposals are particularly invited for the following four (4) research and development areas for the AGR fuel development program:

· AGRF-1: Evaluation of Natural Graphite Properties after Adsorption of Fission Products. Develop a detailed evaluation, experimental testing program, and data table focused on the property changes of graphite after adsorption of fission products would be beneficial in predicting the quality of a fuel compact, as well as its lifetime in a reactor. AGR fuel compacts are currently being produced using the German overcoating methodology. The overcoat is the so-called A3 matrix of natural graphite (64 wt. %), synthetic graphite (16%), and thermosetting resin binder (20%). The natural graphite contains impurities in the form of metallic inorganics that may act as active sites for adsorption of gaseous fission products like CO, CO2, or other species. It is unknown whether the adsorption of such gases would incur structural damage to the A3 matrix, and if the rate of adsorption is related to the amount and type of impurities present. The suggested studies for the A3 matrix materials would include testing the adsorptive capabilities of the graphites for CO, CO2, and other potential gaseous fission products, graphite property characterization with these absorbed gases, and the development of a table that shows the reactivity of a given metallic impurity toward adsorption of a given gaseous fission product

· AGRF-2: Transport Behavior of Fission Products in TRISO Coated Particles. Develop a model of fission product transport through the pyrolytic carbon and silicon carbide coating. An understanding of the transport of fission products through the pyrolytic carbon and silicon carbide layers of TRISO-coated particle fuels is needed to characterize the radiological source term for the Very High Temperature Reactor. While the transport behavior has been inferred from integral fission product release measurements on fuel elements (e.g., pebble or compact), uncertainties remain in both the transport behavior and the mechanisms underlying the transport (e.g., diffusion, trapping, intercalation, sorption/desorption). With the recent advances in computational material science tools, the use of first principles kinetic Monte Carlo methods may provide information that could reduce uncertainties, elucidate transport mechanisms and/or provide estimates for transport behavior where measurements are either impractical or cost prohibitive. We invite proposals that would attempt to use such model to describe the transport of noble gases, iodine, tellurium, cesium, strontium, silver, palladium, and rare earth fission products in the layers of the TRISO coated particle fuel under both normal and accident conditions.

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· AGRF-3: Development of an Improved Sorption Measurement Technique. Develop an improved sorption measurement technique to measure the accumulation of condensable radionuclides (“plateout”) in the primary coolant circuits of VHTRs. Of particular concern, the expected plateout on the turbine of a direct-cycle MHR will produce significant radiation fields that will complicate plant design, operation and maintenance, and safety. It is essential that the reactor designer have the capability to reliably predict fission product transport in VHTR primary coolant circuits. To that end, design methods have been developed, and these methods have been applied extensively to support the design and safety analysis for various VHTRs. The uncertainties in such predictions are quite large (>>10x); a key reason is very large uncertainties in the material property data, especially the sorption isotherms, used as input to these design methods. The limited available sorption data for describing the deposition of condensable radionuclides on structural materials has been summarized and correlated as sorption isotherms. There are a number of generic deficiencies in these data. First, there are few data for typical turbine blade materials (e.g., IN100, Inconel 617, etc.). Moreover, with the exception of the tungsten data, these sorption measurements were made at partial pressures that are orders of magnitude higher than those predicted for the reactor during normal operation with high-quality fuel (e.g., 10-17 to 10-13 atm); consequently, the sorption isotherms derived from these data are extrapolated some four to six orders of magnitude when used in reactor analysis. Thus, an improved experimental technique needs to be developed and qualified for measuring the sorptivities of structural metals for Ag, Cs, Te and I at partial pressures, temperatures and oxidation potentials that are representative of the predicted conditions in the primary coolant circuits of VHTRs. In particular, the experimental challenge is to measure sorptivities at radionuclide partial pressures <<10-10 atm.

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· AGRF-4: Scaling Relationships for Fluidized Bed CVD Coating. Develop scaling relationships for the fluidized bed chemical vapor deposition (CVD) coating process used for fabricating TRISO fuels. The AGR fuel program is engaged in designing a pilot-scale nuclear fuel particle coater to apply pyrocarbon and silicon carbide coatings by CVD on uranium oxycarbide kernels for TRISO-coated fuels. The applicability of Glicksman's dimensionless scaling relationships1-2 for high-temperature (⩽1500°C), spouted-bed fuel coaters needs to be verified and the sensitivities of the relationships quantified. Particle-particle interaction forces3 cannot be ignored and rapid thermal expansion of the reactive coating gases needs to be considered. Investigators will collect data using physical models that are scaled to be hydrodynamically similar to the 6-inch fuel coater being tested by the AGR program team.

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References: 1. Glicksman, L. R., "Scaling Relationships for Fluidized Beds," Chem. Eng. Sci., Vol 39 (1984), No. 9, pp. 1373 – 1379. 2. Glicksman, L. R., M. Hyre, and K. Woloshun, "Simplified Scaling Relationships for Fluidized Beds," Powder Technology, Vol. 77 (1993), pp. 177 – 199. 3. He, Y.-L., C. J. Lim, and J. R. Grace, "Scale-up Studies of Spouted Beds," Chem. Eng. Sci., Vol 52 (1997), No. 2, pp. 329 – 339.

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Materials Research and Development

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The VHTR Materials R&D Program will focus on testing and qualification of the key materials commonly used in VHTRs. The materials R&D program will address the materials needs for the VHTR reactor, intermediate heat exchanger, and associated balance of plant.

The program is being initiated before the formal design effort to ensure that appropriate data will be available to advance the VHTR design concept. The thermal, environmental, and service life conditions of the VHTR will make selection and qualification of some high-temperature materials a significant challenge; thus, new materials and approaches may be required. The following materials R&D areas are currently addressed in the R&D being performed or planned:

· Qualification and testing of nuclear graphite and carbon fiber/carbon matrix composites. Significant quantities of graphite have been used in nuclear reactors and the general effects of neutron irradiation on graphite are reasonably well understood. However, models relating structure at the micro and macro level to irradiation behavior are not well developed. Most of the past work was specific to a graphite known as H-451, which is no longer available. Therefore, the currently available nuclear grade graphites must be tested and qualified for use in the VHTR.

The graphite fuel and moderator blocks are subjected to compressive stress due to the mass of the core, and tensile and compressive stresses because of thermal gradients and irradiation-induced graphite dimensional changes. When the reactor shuts down, the stresses generally reappear in the opposite (tensile) direction and block failure may occur. An Advanced Test Reactor (ATR) creep capsule will be built in FY-06 and irradiation testing will commence in FY-07 to evaluate this phenomena.

· Development of improved high-temperature design methodologies. The High-temperature Design Methodology (HTDM) project will develop the data and simplified models required by the ASME B&PV Code subcommittees to formulate time-dependent failure criteria that will ensure adequate high-temperature metallic component life. This project will also develop the experimentally based constitutive models that will be the foundation of the inelastic design analyses specifically required by ASME B&PV Section III, Division I, Subsection NH. This effort is needed because the current high-temperature design rules are based on separation of time and rate-independent responses or on strain-hardening idealizations. These rules are adequate at lower temperatures but breakdown at higher temperatures. Alloys 617 and Grade-91 steel have been selected for use in the initial improved HTDM development.

· Expansion of American Society of Mechanical Engineers (ASME) Codes and American Society for Testing and Materials (ASTM) Standards to support the VHTR design and construction. Much of this effort will provide required technological support and recommendations to the Subgroup on Elevated Temperature Design (NH) as they develop methods for use of Alloy 617 at very high temperatures. ASME design code development is also required for the graphite core support structures of the VHTR and later for the Cf/C composites structures of the core. A project team under Section III of ASME is currently undertaking these activities.

· Improving understanding and models for the environmental effects and thermal aging of the metallic alloys. The three primary factors that will most affect the properties of the metallic structural materials from which the VHTR components will be fabricated are the effects of irradiation, high-temperature, and interactions with the gaseous environment to which they are exposed. This work is focused on assessing the property changes of the metallic alloys as a function of exposure to the high-temperature and impure gas environments expected in the VHTR.

· Irradiation testing and qualification of the reactor pressure vessel materials. Some VHTR designs assume the use of higher alloy steel than currently used for LWR pressure vessels. If these materials are to be used, then the irradiation damage and property changes of these materials must be measured.

· Qualification and testing of the silicon carbide fiber/silicon carbide matrix composite materials needed for the VHTR. Composite materials have higher strength than their base material, especially in tension; higher Weibull modulus (resulting in more uniform failure); and much higher damage tolerance (fracture toughness). This program is directed at the development of C/C and SiC/SiC composites for use in selected very high temperature/very high neutron fluence applications such as control rod cladding and guide tubes (30 dpa projected lifetime dose) where metallic alloy are not feasible. It is believed that SiC/SiC composites have the potential to achieve a 60-year lifetime under these conditions. The usable life of the C/C composites will be less, but their costs are also significantly less. The program will eventually include a cost comparison between periodic replacement of C/C materials and use of SiC/SiC composites.

· Assessment of fabrication and transportation issues relating to the VHTR reactor pressure vessel. Materials issues associated with joining and inspecting heavy section forgings are covered in this task.

· Development of a materials handbook/database to support the Generation IV Materials Program. This is required to collect and document in a single source the information generated in this and previous VHTR materials R&D programs.

· VHTR reactor pressure vessel emissivity. The emissivity and other physical and mechanical properties of layers that form either by high-temperature environmental exposure or artificially engineered layers on the exterior surface of the VHTR reactor pressure vessel will be measured. These data are needed for off-normal and accident condition assessments.

We envision that university projects in the areas of composite development and testing, VHTR component testing, and high temperature metals testing and design methodology development would be particularly valuable.

Design Methods Development and Validation

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Areas of relevant VHTR methods development and validation are described in the tasks below.

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· CFD Code Validation Experiments. Additional data for CFD software validation are required to supplement the turbulent mixing data in the literature. The needed data will be applicable to the prismatic block and pebble-bed gas-reactor lower plenums available and initially collected in a large matched index of refraction (MIR) facility located at INL. This work will include scaling studies, completion of the conceptual design and then fabrication of the lower plenum experiment, and a limited number of experiments.

.

Experiments are also needed (1) to evaluate the effects of temperature variations on turbulent mixing in the lower plenum and (2) to determine turbulence quantities in heated vertical channels for evaluation of proposed CFD turbulence models. The former would supplement the MIR experiments discussed above. A conceptual design of these experiments has been completed and fabrication of the experimental equipment will begin in FY-06.

.

· Validate Thermal-Hydraulic Software. This work will involve validation of commercial Computational Fluid Dynamics (CFD) software using literature data regarding jets in plenum with cross-flow present. We will also perform CFD calculations to support experiment design. The RELAP5 heat transfer models will be improved for reactor core analyses and validated. And, CFD calculations will be performed to characterize heat transfer processes in the reactor cavity and reactor cavity cooling system.

.

· Core Physics Methods Development. This work will involve the definition of a complete suite of codes to perform accurate and valid neutronics analyses for VHTRs and identify and begin implementation of needed modifications. The program will also improve an existing cross section generation code to properly treat low energy resonances and doubly heterogeneous fuel using Dancoff factors, and assess modeling requirements for characterization of temperature-dependence of displacement threshold energy.

.

· The INL Nuclear Data Initiative. Computer codes used for physics analysis of nuclear systems must be benchmarked against appropriate integral experiments to ensure accuracy of computed parameters such as reactivity, flux spectrum, reaction rates, etc. This work is being coordinated with an OECD International Reactor Physics Benchmarking Program, chaired by INL. This builds on historical INL capabilities in reactor physics and the benchmark assessment completed in FY-04 with crosscut funding.

.

· Molten Salt-Cooled Methods Development and Design Assessment. Four liquid salt coolants have been implemented into the RELAP5-3D code to support required VHTR analyses. The salts are Li_2BeF_4 (flibe), LiFNaFKF (flinak), 92%$NaBF_4$-8%NaF, and 50%NaF-50%ZrF_4. Flibe and 50%NaF-50%ZrF_4 are currently the leading contenders for the primary coolant in the Liquid Salt-Cooled VHTR, while flinak and 92% NaBF4-8%NaF are leading candidates for the intermediate heat transport loop. The implementation was based on a simplified equation of state.

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Thermal-hydraulic analyses are now being conducted to support the pre-conceptual design of the liquid salt-cooled VHTR. In addition, a Monte Carlo core model has been developed for studies of key reactor physics parameters including fuel loading, temperature and void reactivity coefficients, and other parameters of interest. This task will define a baseline molten salt-cooled VHTR concept.

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2.2 Sodium Fast Reactor

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The SFR relies primarily on technologies already developed and demonstrated for sodium-cooled reactors and associated fuel cycles that have successfully been built and operated in worldwide fast reactor programs. As a benefit of these previous investments in SFR technology, the majority of the R&D needs that remain for the SFR are related to performance rather than viability of the system. Therefore, no technical “show-stoppers” are anticipated for SFR reactor technology. The primary issues that may inhibit SFR introduction are:

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• a perception of higher capital costs, as compared to conventional LWR technology
• unique concerns related to liquid metal sodium as a coolant (in particular, coolant reactions with air/water, and component access under sodium)

.

Thus, the required research and development (R&D) activities focus on the items addressed above with an emphasis on improved SFR economics, in-service inspection and repair, verification of inherent safety behavior, and advanced simulations. A comprehensive international R&D program for SFR technology has been created as part of the Generation-IV International Forum. The detailed research plan includes the relevant reactor and fuels technology; some key R&D goals and products are summarized in this section. (The Generation-IV "Draft R&D Program Plan for the Sodium Fast Reactor (SFR)" revision April 2006 includes an itemized research plan and schedule for international R&D collaborations.)

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For future SFR systems, it is important to achieve a level of economic competitiveness that enables system utilization in accordance with market principles. For this purpose, an important goal is to ensure competitive energy cost (per unit power generation) compared with other energy sources. To this end, a variety of innovative design features are being considered:

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1. Configuration simplifications. These include reduced number of coolant loops by improving the individual loop power rating, improved containment design, refined (and potentially integrated) component design, and possibly elimination of the intermediate coolant loop. In addition, the flexibility of the core configuration must be considered for diverse fuel cycle missions (burner or breeding) and their potential impact on capital and fuel cycle costs.

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2. Improved O&M technology. Innovative ideas are being considered for in-service inspection and repair. Remote handling and sensor technology for use under sodium are being developed, including ultra-sonic techniques. In addition, increased reliability for sodium-water steam generators is being pursued by advanced detection and diagnostic techniques.

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3. Advanced reactor materials. The development of advanced structural materials may allow further design simplification and/or improved reliability. These new structural materials need to be qualified, and the potential for higher temperature operation evaluated.

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4. Advanced energy conversion systems. The use of a supercritical CO_2 Brayton cycle power generating system offers the potential for surpassing 40% efficiency; a more compact design may also be possible. Cost and safety implications must be compared to a conventional Rankine steam cycle balance-of-plant design. More detail on this issue is also given in the Energy Conversion section of this Appendix.

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With regard to reactor safety, technology gaps center around two general areas: assurance of passive safety response, and techniques for evaluation of bounding events. The advanced SFR designs exploit passive safety measures to increase reliability. The ability to measure and verify these passive features must be demonstrated. The system behavior will vary depending on system size, design features, and fuel type.

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5. SFR Safety Design and Analysis. R&D for passive safety will investigate phenomena such as axial fuel expansion and radial core expansion, and design features such as self-actuated shutdown systems and passive decay heat removal systems. Associated R&D will be required to identify bounding events for specific designs and investigate the fundamental phenomena to mitigate severe accidents.

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Finally, the development and application of advanced modeling and simulation tools is a key activity in the GNEP. These tools are intended to refine the scientific modeling and improve accuracy and precision of design and performance analyses. These new techniques will also exploit modern computational hardware and software for nuclear fuel cycle applications.

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6. Improved reactor simulation and design integration. The application of modern design rules and new codes may allow significant reductions of the conservative margins employed in previous fast reactor designs.

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2.3 Design and Evaluation Methods Development

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The listing of R&D needs below is organized according to programmatic activity categories.
This program element seeks to provide and validate analysis tools for design of Generation IV systems and confirmation of their safety. These analysis tools include modeling approaches, computer codes and databases used to represent neutronic, thermal, fluid-flow and structural phenomena in steady state and transient conditions. They also include capabilities for representing the mutual coupling among these phenomena and their coupling with additional phenomena (e.g., fuel behavior, fission gas release, materials damage, chemical reactions, etc.) for which models are created in other elements of the Generation IV, Advanced Fuel Cycle Initiative, and Nuclear Hydrogen Initiative programs. Modeling advances that are targeted reduce uncertainties in predicted system behavior and contribute to developing optimized Generation IV system designs.

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To ensure the relevance of proposed modeling approaches and their cost effective implementation, the following strategy has been adopted for D&EM research:

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· Establish modeling requirements for each system, working with the System Integration Manager and the GIF project management board responsible for system design development and safety confirmation,

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· Assess the adequacy of existing tools and databases by examining their capabilities relative to the requirements, identifying gaps, and comparing predictions against results that are independently obtained through measurement or analysis,

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· Implement required modifications to the analysis methods and define the needs for new measurements,

.

· Validate the models and analysis methods by confirming their ability to simulate the physical phenomena of interest with sufficient accuracy and precision.

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Both initial assessment and validation of models are based substantially on comparisons with measurements. Identification of relevant measurements and determination of the need for additional measurements are thus included as an integral part of the D&EM work scope.

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Some of the required analysis capabilities are crosscutting in that they are applicable to multiple Generation IV systems. Examples are Monte Carlo and deterministic transport methods for neutronics modeling, modern computational fluid dynamic (CFD) methods for heat transfer and fluid flow simulation, and modular code systems for fuel cycle evaluations and simulation of transients and postulated accidents. Advances in these capabilities will help reduce uncertainties in predicted system behavior, which can be exploited in system development by targeting the best performance achievable within the capabilities or limits of the technologies employed by the system.

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A need has also been identified in the Generation IV Roadmap to advance methodologies for evaluating overall system performance against the Generation IV goals of sustainability, economics, safety, reliability, proliferation resistance, and physical protection. Compared to methodologies previously used for such evaluations, new methodologies are needed that are more quantitative, feature an improved process for employing expert judgment, enable estimation of uncertainty in evaluated performance, better represent unique features of Generation IV systems, and account more comprehensively for important factors influencing performance. Application of these methodologies will help guide the R&D on Generation IV systems and provide a basis for judging the success of the R&D as it progresses, as well as for selection of preferred systems and system technology options.
The overall timeline for D&EM research conforms with and supports the timelines for developing the Generation IV systems. Accordingly, the first five years are devoted to providing the capabilities needed for

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(a) resolution of viability issues for Generation IV systems,

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(b) development of a high-performance VHTR design, and

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(c) down-selection among fast reactor systems.
.
Additionally, there is early emphasis on establishing the evaluation methodologies, so that they may be used for evaluating progress toward the Generation IV goals and in choosing among system technologies and design alternatives.
.
In the second phase of the program, the analysis methods will be increasingly focused on the specific designs adopted for the VHTR and on the development needs of other Generation IV systems. These methods will be formally qualified for use in design development and licensing. Moreover, in this second phase, the evaluation methodology efforts will increasingly be directed to evaluations of system designs and verification of performance advances.
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2.4 Crosscutting Materials Development for Advanced Reactors
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The listing of some R&D needs below is organized according to programmatic activity categories.
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To make efficient use of program resources, the development of the required databases and methods for their application must incorporate both the extensive results from historic and ongoing programs in the United States and abroad that address related materials needs. These would include, but not be limited to, DOE, NRC, and industry programs on liquid-metal-, gas-, and light-water-cooled reactor, fossil-energy, and fusion materials research programs, as well as similar foreign efforts.
.
Since many of the challenges and potential solutions will be shared by more than one reactor concept, it will be necessary to work with the system integration managers (SIMs) for each individual reactor concept to examine the range of requirements for its major components to ascertain what the materials challenges and solutions to those will be and then establish an appropriate breakdown of responsibilities for the widely varying materials needs within the Generation IV Initiative. There are two primary categories for materials research needs:
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· Materials needs that crosscut two or more specific reactor systems and
.
· Materials needs specific to one particular reactor concept or energy conversion technology.
.
Where there are commonly identified materials needs for more than one system, a crosscutting technology development activity has been established to address those issues. Where a specific reactor concept has unique materials challenges, it will be appropriate to address those activities in conjunction with that particular reactor systems' R&D. Examples of this category of materials needs include reactor-specific materials compatibility issues associated with a particular coolant and materials used within only one reactor concept (i.e. graphite within the VHTR).
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The National Materials Program within the Generation IV Initiative will establish and execute an integrated plan that addresses cross-cutting, reactor-specific, and energy-conversion materials research needs in a coordinated and prioritized manner.
.
Four interrelated areas of materials R&D are generally considered crosscutting:
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(1) qualification of materials for service within the vessel and core of the reactors that must withstand radiation-induced challenges;
.(2) qualification of materials for service in the balance of plant that must withstand high-temperature challenges;
.(3) the development of validated models for predicting long-term, physically based microstructure-property relationships for the high-temperatures, extended-operation periods, and high irradiation doses that will exist in Generation IV reactors; and (
.4) the development of an adequate high-temperature-materials design methodology to provide a basis for design, use, and codification of materials under combined time-independent and time-dependent loadings.
.
Reactor-specific materials research that has been identified for the individual reactor and energy-conversion concepts includes materials compatible with a particular coolant or heat-transfer medium, as well as materials expected to be used only within a single reactor or energy conversion system, such as graphite, selectively permeable membranes, catalysts, etc. A special category of reactor-specific materials research will also include research that must be performed at pace that would significantly precede normal cross-cutting research in the same area (e.g. VHTR reactor system materials R&D).
.
While materials issues for all the reactors currently included within DOE's Generation IV program, there is recognition that the plans to advance a VHTR design will strongly drive much of the materials research

during the next ten years of the program. Accordingly, though the four crosscutting activities will include materials of interest to all the reactors, where possible, the emphasis will be on materials that meet the needs of the VHTR, while at the same time supporting the other reactor concepts. Where the VHTR materials needs clearly outstrip those of the other reactor systems, they will be addressed independently and the other reactor systems will be able to utilize those results that are relevant.

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A final category of materials R&D that is recognized within the Generation IV Program is, that which overlaps the materials, needs for the development of fuels and reprocessing technology within the Advanced Fuel Cycle R&D Program (AFC R&D) and for chemical processing equipment for the Nuclear Hydrogen Initiative (NHI). While both AFC R&D and NHI are independent programs with their own research objectives and funding, it has already been recognized their applications will contain many of the same conditions that exist for reactor systems and their components in the Generation IV Program and, hence, may utilize a common set of structural materials. A special involvement among all three programs is being developed and maintained to help ensure that the materials R&D being conducted within them is coordinated to minimize duplication and costs and maximize mutually beneficial materials technology development and qualification.

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The high-level objectives for the Generation IV Reactor Materials Program through FY09 are:

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· Complete PIE for low-dose scoping irradiations of commercial and near-commercial materials.

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· Initiate low-dose scoping irradiations of ceramics, ceramic composites, and advanced metallic materials

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· Structure an integrated experimental and modeling approach to investigate radiation effects issues that crosscut the four reactor concepts, with emphasis on critical areas

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· Perform detailed analysis of available reactor facilities that will accommodate irradiation capsules at conditions needed for high flux-high temperature irradiations for GFR and LFR, and low flux-high temperature irradiations for VHTR

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· Initiate joining and combined-effects screening studies on commercial and near-commercial alloys.

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· Perform scoping evaluation of Friction Stir Welding of advanced alloys

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· Evaluate initial population of historical data in materials database

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· Complete population of Generation IV Materials Handbook with available historical data, and initiate additions of advanced materials data and new data developed in Generation IV Program

.

· Initiate extension of materials database for data developed by GIF partners

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· Prepare documents of alloy 617 for ASME codification.

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· Provide interim constitutive equations for 9 Cr, Grade 92 steel and Alloy 617 to aid in Code development and design studies.

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· Prepare interim report on results of model-based nucleation phase of the significant extended defects produced under irradiation.

.

· Prepare updated, status report on assessment and selection of crosscutting candidate materials for high-temperature and radiation service in Generation IV reactor systems.

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· Complete low-dose scoping irradiations and PIE of advanced materials

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· Complete selection of primary RPV candidate materials based on screening irradiation experiments.

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· Continue studies of time-dependent mechanical properties combined-effects on commercial and near-commercial alloys

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· Continue detailed studies of high-temperature, time-dependent properties for advanced candidate materials for high-temperature service and required materials modifications

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· Continue joining studies on commercial and near-commercial alloys and initiate joining studies on advanced high-temperature materials

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· Complete development of evaluated description of historical data in Generation IV Materials Handbook

.
· Initiate constitutive equation development activities for other key common Generation IV component materials.
.
· Propose validated creep-fatigue failure criteria for 9 Cr, Grade 92 steel and Alloy 617, or a variant thereof.
.
· Complete Alloy 617 confirmatory structural tests and initiate testing of models for other key Generation IV structural materials
.
· Prepare interim report describing overall microstructural evolution under low and high temperature irradiation; include results from preliminary modeling studies and microstructural characterization.
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· Prepare interim report on mechanisms responsible for the development of radiation-enhanced, -induced, and -modified microstructural changes.
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· Prepare report on overall assessment and interim selection of assessment and selection of crosscutting candidate materials for high-temperature and radiation service in Generation IV reactor systems.
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2.5 Energy Conversion
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The listing of R&D needs below is organized according to programmatic activity categories.
Supercritical CO2 Power Conversion Cycles
.
· The compression stage of a supercritical CO2 cycle involves operation near the critical point of CO2. Examine analytical tools for S- CO2 power conversion cycles and develop improved models for near critical point operation, including working fluid properties, thermodynamic analysis and turbomachinery design.
.
· Evaluate S-CO2 dynamic response to startup and off normal operation. Investigate inventory or other control mechanisms for system operation. Develop innovative load-following approaches as an alternative to inventory control.
.
· Identify requirements for a small-scale experiment to demonstrate the key technology and operational features of the supercritical CO2 cycle. Perform analysis to define experiment scale and verify performance.
.
· Evaluate the use of radial turbomachinery, especially compressors, in place of axial compressors for the S- CO2 cycle.
.
· Develop and test shaft seal and bearing designs for use in S-CO2 bearing tribology tests.
.
· Evaluate the S-CO2 cycle as a bottoming cycle on the VHTR thermochemical H2 unit; evaluate a bottoming cycle for S-CO2 cycles; devise a practical CO2 condensing cycle version.
.
· Evaluate costs and benefits of using inverters to allow non-synchronous shaft rotational speeds for S-CO2 turbines.
.
· Perform steady state and transient pressure/ thermal/ combined stress analyses of turbines, compressors and other key components for supercritical CO2 conceptual designs.
.
· Evaluate 2 and 3 shaft turbomachinery layouts to compare to single and multiple shaft configurations.
.
High-Temperature Brayton Cycle Studies.
.
· Develop innovative heat exchanger designs for interstage heating and cooling for high- temperature inert gas Brayton cycles that minimize temperature and pressure drops for both liquid-gas and gas to gas heat exchangers.
.
· Develop algorithms for optimization of Brayton cycle configurations, efficiency and cost to allow comparison of advanced cycle configurations.
.
· Perform analyses to evaluate experimental requirements for a viable small scale high temperature He Brayton cycle test to demonstrate efficiency improvements for interstage heated, cooled or other cycle configurations. Develop a preliminary design for major components.
.
· Investigate single vs. multiple shaft configurations and non-synchronous shaft rotational speeds using

invertors and evaluate economic and operational implications.
.
· Perform analyses to compare direct vs. indirect cycle approaches for high temperature reactors. Identify engineering approaches to minimize or mitigate efficiency, cost implications for indirect cycles, or mitigate operational and maintenance impacts of direct cycles.
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3. Nuclear Hydrogen Initiative
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3.1 Thermochemical Cycles
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The listing of some R&D needs below is organized according to programmatic activity categories.
Sulfur-Iodine Cycle
.
· Investigate alternative approaches to separation of two acids from Bunsen reaction section (H_2SO_4 and HI) to reduce the cycle's iodine inventory and recycle.
.
· Develop innovative heat exchanger approaches for the high temperature sulfuric acid sections that minimize materials corrosion impact on heat exchanger viability by using sacrificial materials, direct contact heat exchange or other engineering approaches to reducing overall materials requirements.
.
· Investigate control issues for closed cycle thermochemical systems and develop preliminary models to examine startup, off normal, and shutdown issues for complex thermochemical plants. Develop preliminary control algorithms for closed loop operation of thermochemical cycles.
Membranes for Sulfur Cycles
.
· Evaluate and/or investigate membranes that may be effective for removing water from HI, I_2, water mixtures at temperatures between 25 and 300 C.
.
· Evaluate and/or investigate high temperature membranes that will be effective at removing oxygen from the product stream of a high temperature sulfuric acid decomposition reactor (H_2SO_4, SO_2 and water).
.
· Evaluate and/or investigate methods that may be effective for the removal of water from sulfuric acid/water solutions prior to entering the sulfuric acid decomposition reactor.
Catalysts for Sulfur Cycles
.
· Develop catalysts that are active for the conversion of SO_3 to SO_2 and oxygen. The catalysts should have long active lifetimes and be of reasonable cost.
.
· Develop catalysts that are active for the conversion of HI to I_2 and hydrogen. The catalysts should have long active lifetimes.
.
Hybrid Sulfur
.
· Investigate improved or alternative materials for anodes, cathodes, and membranes materials for H_2SO_3 electrolysis.
.
Thermochemical Cycle Analysis and Alternative Cycles
.
· Identify alternative thermochemical cycles (not current baseline) for nuclear hydrogen production that have potential for higher efficiency, lower temperature operation or are less complex, but are not presently characterized to determine viability.
.
· Perform flowsheet analyses to characterize process(es), in order to allow assessment of performance potential and preliminary comparison with baseline cycles.
.
· Identify basic thermodynamic data or laboratory experiments for alternative cycles that are needed to improve assessments.
.

The NHI thermochemical cycles area seeks NERI proposals in two areas in FY07:

· Analytic and lab scale proof of concept experimental studies related to alternative cycle evaluation such that process chemistry, kinetics and efficiency can be better defined. Cycles of primary interest have been identified by current work in FY05 and FY06 by Argonne National Laboratory.

· Enabling research in the cross cutting areas of catalysis and product separation that support one or more of the cycles of interest and addresses the major challenges of high temperature, corrosive conditions, and equilibrium limitations to conversions.

3.2 High Temperature Electrolysis

This element of the Nuclear Hydrogen Initiative focuses on developing components and overall designs for splitting steam into hydrogen and oxygen using high-temperature solid-oxide electrolyzer cells (SOECs). The technology is derived from the materials and configurations now used in solid oxide fuel cells (SOFCs). At the 750-900 °C operating temperatures of SOECs, as much as 30% of the energy for electrolysis may be supplied thermally, increasing the overall efficiency of the process to 45 - 55%. The high-temperature electrolysis (HTE) project has conducted several multiple-cell stack experiments using 10 x 10 cm planar cells to investigate the thermal and electrochemical performance of the electrolyte, electrodes and the interconnection plates. A recent stack test utilized a 25-cell stack that produced hydrogen at an average production rate of 177 NL/hr over a 1000-hr test. The long-duration tests are designed to identify and understand mechanisms of cell degradation due to corrosion, creep, cell leakage, material transport and other mechanisms in high temperature operation.

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In addition, the project is developing conceptual designs for the series of experiments needed to demonstrate the HTE concept on a commercial scale when attached to a 600-MWth VHTR. Besides the cells themselves, this design activity is determining requirements for components, electrical power control, steam-hydrogen separations and hydrogen and oxygen cooling. Finally, the project is investigating methods for reducing the overall costs of hydrogen production through HTE. An engineering process model has been developed to investigate the behavior of a full-scale HTE plant under various operating conditions.

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3.3 Reactor-Hydrogen Production Process Interface

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The System Interface and Support Systems activity consists of three interdependent areas of responsibility. These areas and their associated boundary assumptions are:

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· Reactor/Process Interface – This task area concerns the development of all connections and interfaces that must be made to connect a high-temperature nuclear reactor to a hydrogen production plant. It is an area of critical importance to the development of nuclear hydrogen capabilities and is the primary focus of the System Interface research area in the near term. It also addresses the operational behavior of such a system, and includes efforts to understand and control potential negative impacts from system or component failures, control functions, or process feedback from one side of the interface to the other, and all work to control or eliminate those negative impacts. The key components in the reactor/process interface area are the high-temperature heat exchangers required to transport thermal energy from the nuclear plant to the hydrogen production plant. This area includes research and development of high temperature heat exchangers and materials of construction.

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· Balance of Plant (BOP) – Balance of plant encompasses all components and systems of the hydrogen production plant that do not directly perform or support the chemical or electrolysis processes involved in generating hydrogen. Examples are heat exchangers that do not provide direct reaction heat, product and byproduct handling systems, waste handling systems, off-gas treatment, water treatment systems, and sampling systems. In general BOP includes all components and systems that are within the plant but are not primary components of the hydrogen generation process. BOP requirements may be highly dependent upon the specific hydrogen production process and operational conditions.

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· Process Infrastructure and Support Facilities – Process infrastructure includes physical space requirements, electrical, non-electrical energy sources, support laboratories, machine shop, spare parts stores, bulking facilities for feedstock, byproducts and waste materials. Infrastructure requirements tend not to be highly dependent upon specific processes other than capacity.

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The scope of the System Interface and Support Systems area is to ensure that all support systems and reactor interface issues and requirements are met and are ready to support the decision process as the different hydrogen generation processes mature towards the pilot and engineering scale decisions.

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Work under the System Interface and Supporting Systems area is taking place in the areas of high temperature materials development and characterization, mechanical designs, balance of plant definition, steady-state and dynamic system modeling, and in system safety and environmental impacts.

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Additional help from the university community through the NERI program is sought on select topics related to the intermediate heat transport loop. These topics are described below.

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· Studies of corrosion chemistry, corrosion control, and system feasibility studies related to the use of

NaBF4-NaF, carbonate-based salts, or other liquid salts not including FLiNaK or FLiBe for use as high temperature heat transfer fluids in the intermediate heat transfer loop. Liquid salts offer the potential to increase thermal transmission efficiency in the intermediate loop because of their higher heat capacities and densities and lower pumping power requirements than gaseous heat transfer fluids. In order to be acceptable, a liquid salt must have a sufficiently low melting point (less than 500 °C), sufficiently high boiling point (above 1000 °C), and be compatible with several proposed materials of construction (e.g., high-nickel alloys, SiC). If a suitable liquid salt candidate is found from batch experiments, the project should culminate in the construction of a flow loop (natural or forced convection) to demonstrate feasibility.

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· Study of the feasibility of applying thermal siphon technology (one-phase or two-phase) to the intermediate heat transport loop. Thermal siphon technology has been suggested as a means to reduce or eliminate the need for high volume pumps and/or compressors in the intermediate loop. If initial analysis work looks promising, the project should culminate in a construction and operation of a laboratory-scale demonstration of the technology that is scaleable to larger sizes (i.e., many megawatts). The fluid(s) used in the thermal siphon must be compatible with proposed materials of construction (e.g., high-nickel alloys, SiC). The thermal siphon system must be capable of delivering thermal energy at temperatures in the range of 850-900 °C over distances that may span fifty to several hundred meters.

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· High temperature (800-1000 °C) isolation valve development. Reliable and nuclear-grade certifiable isolation valves are needed to protect the high temperature nuclear reactor from failures in the high pressure helium piping or breaches in the intermediate heat exchanger(s). Such automatic safety valves may also be useful to prevent loss of fluid inventory from the intermediate heat transport loop and the communication of stored energy from the intermediate loop into the hydrogen production plant if the interface/process heat exchanger were to fail. Isolation valves are an integral component of existing commercial nuclear systems, but no standardized designs yet exist for high temperature gas-cooled reactors. Project(s) are sought in this area that would lead to designs that could be tested at the lab- and pilot-scale under expected operating conditions.

APPENDIX II

Websites

The Department of Energy is seeking applications from universities for research and development (R&D) that will directly support its nuclear energy R&D in the Advanced Fuel Cycle R&D Program, Generation IV Nuclear Energy Systems Initiative, and Nuclear Hydrogen Initiative programs. Information describing these programs, may be found on the following web sites:

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Office of Nuclear Energy website, http://nuclear.gov

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DOE Hydrogen website, http://www.hydrogen.energy.gov

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Nuclear Energy Research Initiative web site, http://neri.ne.doe.gov

Safety Requirements Document web site,

http://www.eere.energy.gov/hydrogenandfuelcells/pdfs/safety_guidance.pdf